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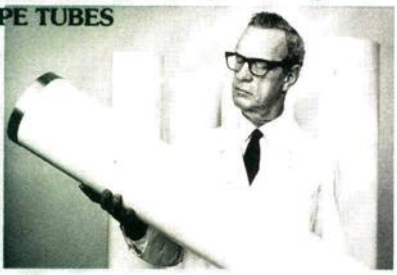

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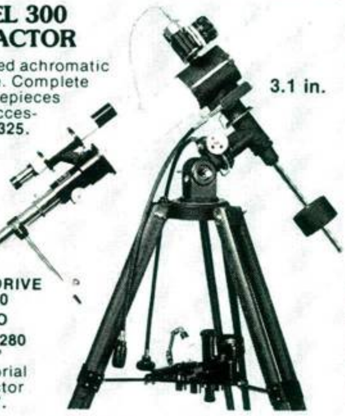

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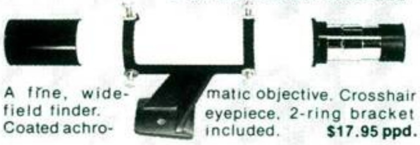

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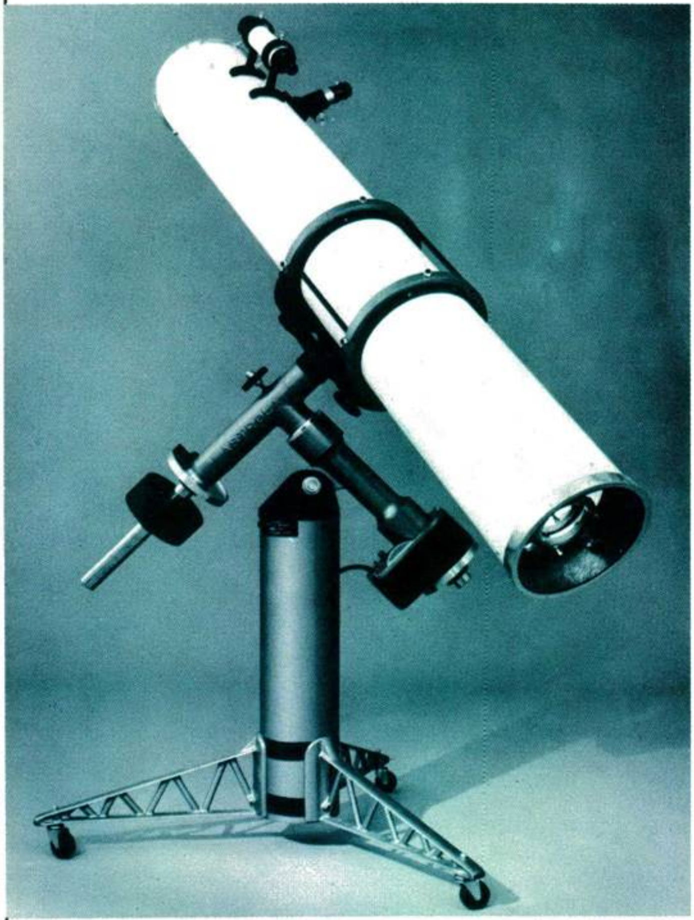

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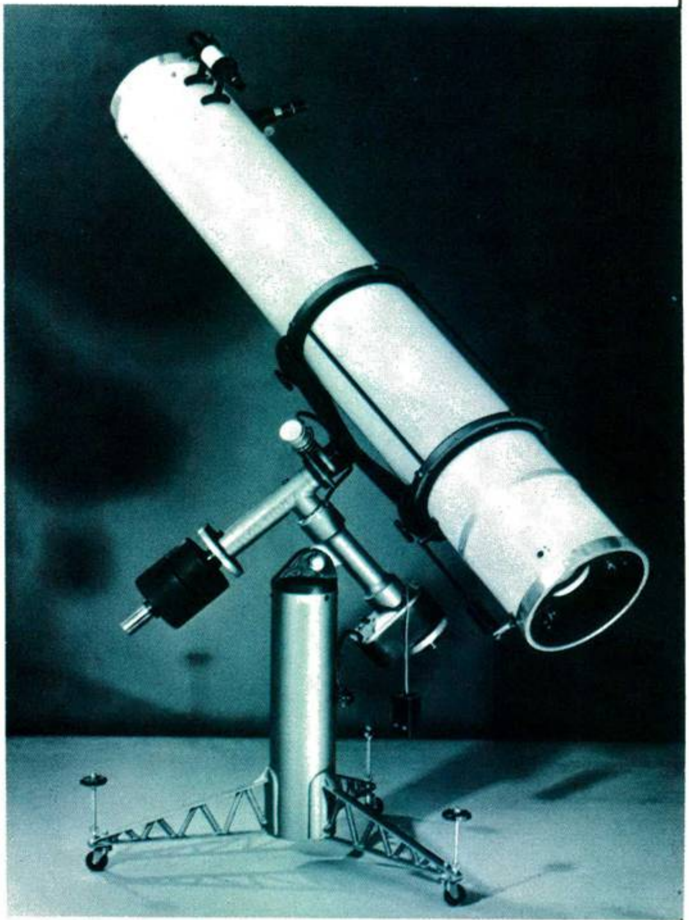

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Cover

Photograph by Leo C. Henzl Jr.

Omega Centauri, one of more than 100 globular clusters, orbits the nucleus of our Milky Way galaxy. A spherical island of perhaps more than one million stars, Omega Centauri is the largest known globular cluster. A relatively faint object, this globular cluster was photographed in a 20 minute exposure on High Speed Ektachrome using an eight inch Celestron Schmidt camera. This special camera is discussed in Photography in Astronomy.

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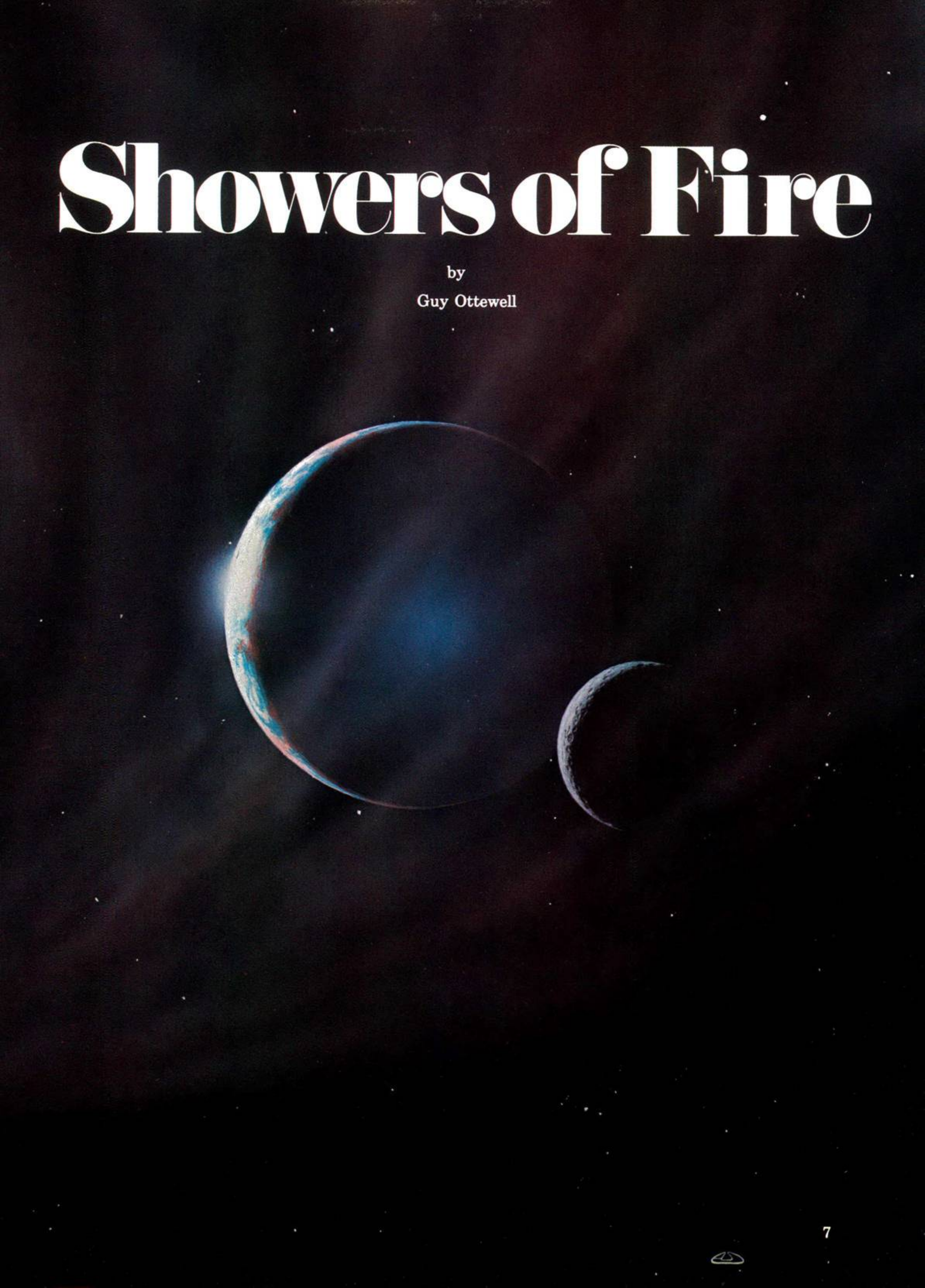
Showers of Fire

by

Guy Ottewell



August is the month of St. Lawrence's Tears.

Laurentius, a Christian deacon, is said to have been martyred by the Romans in 258 A.D. on a hot gridiron. It is doubtful whether this actually happened or was a product of morbid medieval imagination — but King Philip II of Spain believed it enough to build his huge monastery-palace, the "Escorial", on the plan of the holy gridiron. The saint's death was commemorated on his feast day, Aug. 10. And late on this night every year, worshipers who happened to glance upward noticed swift flashes coursing from the northeastern sky. There might be two in quick succession; a couple of minutes later, another.... Surely, these were the scalding tears of the martyr!

Until recently, this was as reasonable a conjecture as any that people could make about these streaks of light.

We can still see the spectacle every year, though now the center of it has shifted to the night of Aug. 12. By watching attentively we can also, on any clear night of the year, see an average of seven sky flashes an hour. The difference between them and the ones of Aug. 12 is not only that they are fewer, but that they shoot in random directions. The flashes of Aug. 12 may appear in any part of the sky, but they all *point away from* one part — the north end of the constellation Perseus.

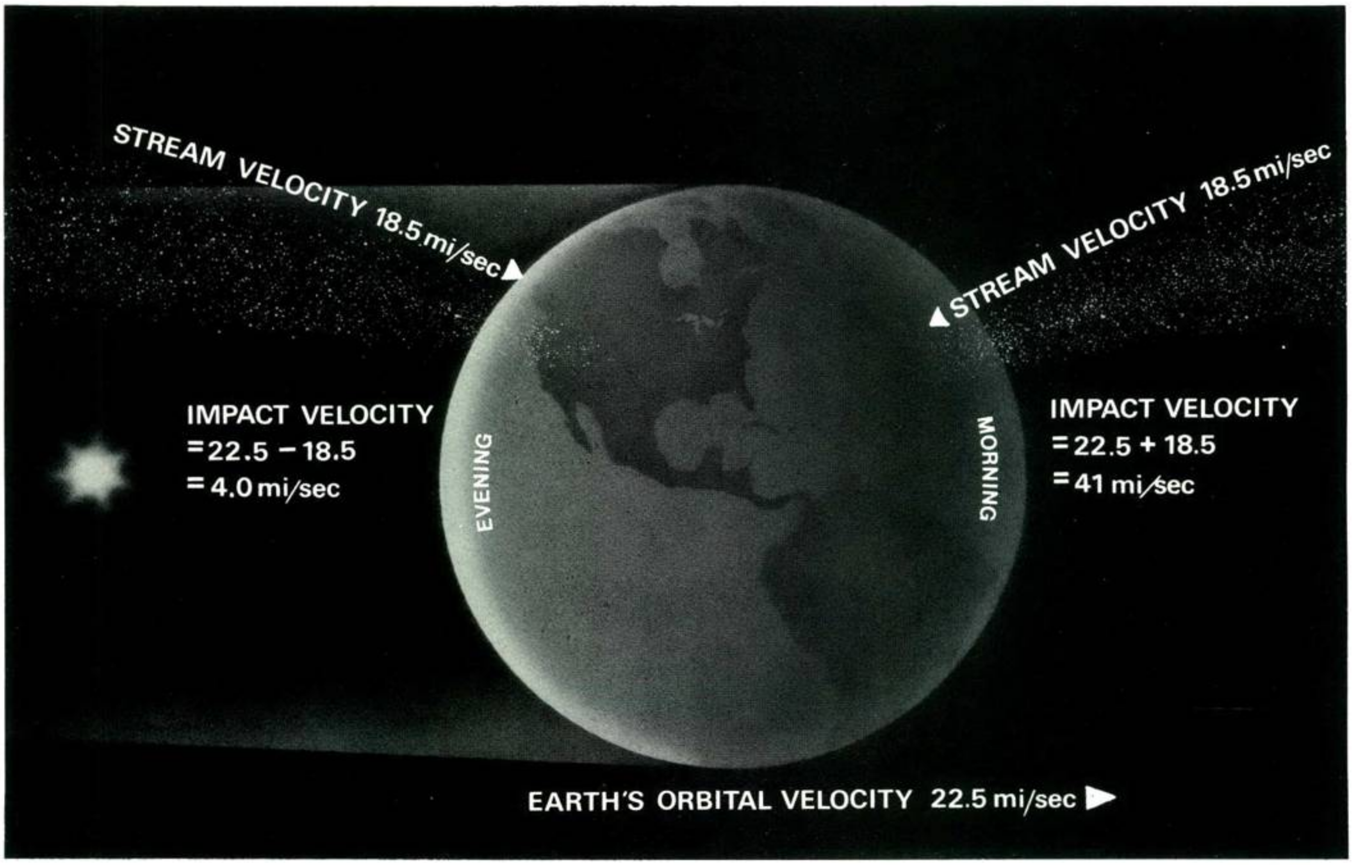
What are all these flashes? They look like signals — omens, perhaps. A Navaho Indian, for example, will not continue to travel in the direction where he sees one: Someone over there has died or will die, and it may be him if he approaches that location. In our own culture, the popular name for the flashes is *shooting stars* or *falling stars*. Many people actually have the impression that what they saw was a star which suddenly sprang from its place and vanished; they assume that if the stars are now counted there will be one fewer.

The somewhat more scientific members of the community classified the flashes along with lightning, hail, raindrops, and other things that fell through the air above us. All were *meteors,* from a Greek word meaning *exalted things.* The rain, hail and snow were *aqueous* (watery) meteors, and the lightning, aurora and night flashes were *fiery* meteors. The whole subject of happenings in the atmosphere was *meteorology.*

Caption for page 6

Earth crosses a river of cometary dust in this stylized view. The endless stream of tiny particles loops around the sun, tracing the parent comet's orbital path. Although such swarms would be virtually invisible in space, their collisions with Earth trigger blazing meteor showers in our atmosphere.

Artwork by Adolf Schaller


STREAM VELOCITY 18.5 mi/sec
STREAM VELOCITY 18.5 mi/sec
IMPACT VELOCITY
=22.5 − 18.5
=4.0 mi/sec
EVENING
MORNING
IMPACT VELOCITY
=22.5 + 18.5
=41 mi/sec
EARTH'S ORBITAL VELOCITY 22.5 mi/sec

Artwork by Victor Costanzo

Meteor swarms can either overtake or collide head-on with Earth. Overtaking showers strike Earth at relatively slow speeds because our planet races away from them at 66,000 m.p.h. orbital velocity. However, particles flying opposite to Earth's orbital direction can scream into the atmosphere at speeds above 100,000 m.p.h. Head-on meteor encounters always occur between midnight and dawn, making the post-midnight hours best for meteor watching.

Finally it was discovered that the night flashes — the only kind that we still call meteors — are in a class of their own. The tale of how this realization dawned is too long to tell here; the most sudden single step in it is recounted under "Leonids" later in this article.

Just as the planets do, billions of tiny solid particles orbit the sun — but in all directions. Seen together, they would fill a vast sphere. When Earth's atmosphere intercepts one of the particles, air friction vaporizes it with a flash of light. This may start 100 to 50 miles above Earth and end a few seconds later at 50 to 20 miles altitude.

Strictly speaking, the word *meteor* is used only for this brief luminous lifetime; while still out in space the particles are called *meteoroids*. A meteor brighter than Venus is a *fireball*. One that breaks up — often with a bang — is a *bolide*. Some are so big that parts of them reach the ground as *meteorites*. And some are so small that they are slowed at once by the thin upper atmosphere and merely drift to Earth as *micrometeorites*, which you can collect on a piece of glass smeared with petroleum jelly.

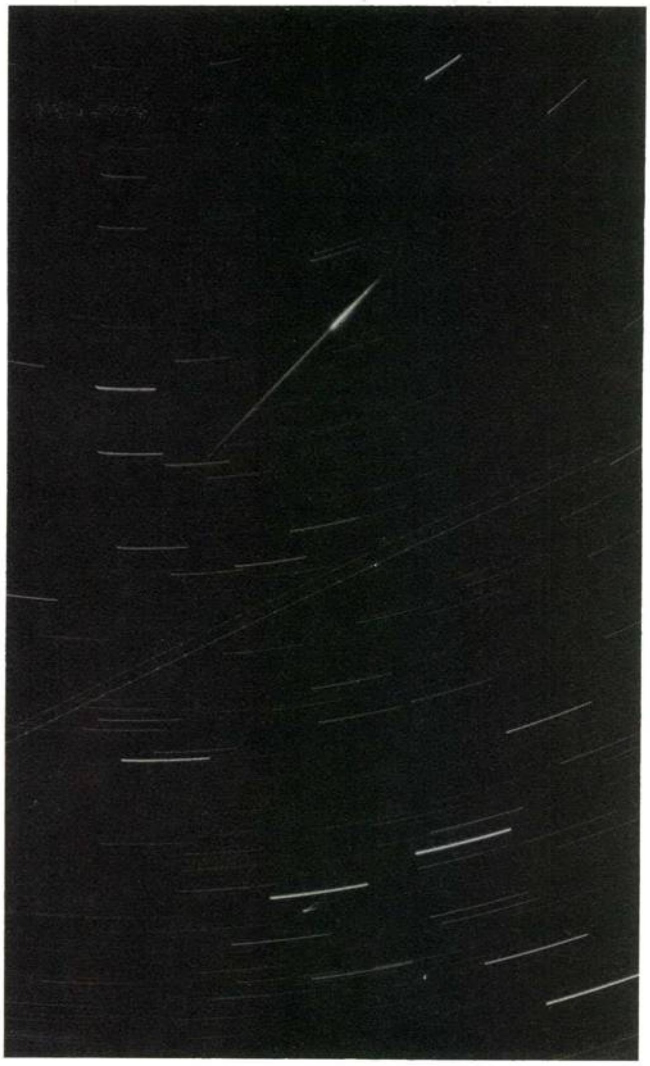
Besides the isolated particles, there are small crowds of them traveling together which have sometimes appeared in the field of a lucky observer's telescope. There are larger crowds which have resulted in 30,000 mile long *meteor processions* across oceans and continents. And there are the great balls of particles clinging together which we call *comets*.

As a comet nears the sun, particles are shed from the nucleus. Thus its orbit is not an imaginary path through space like Earth's, but a continuous river of dust moving in the same direction as the comet.

Every time Earth crosses one of these dust rivers, it stops millions of orbiting particles, and an alert observer may see the few hundred that rain from the air over his location. Though they strike the atmosphere parallel to each other, they also strike roughly toward the observer. Therefore, they do not appear to mark parallel trails on the sky, but fly wider apart as they approach. The point from which the meteors appear to emanate is their *radiant*.

There are a dozen annual showers, and hundreds or thousands of minor ones (mostly so weak that the word "shower" is a great exaggeration). You might see only one meteor, or in some years none at all. It seems in these cases that the parent comets disintegrated into meteor streams long ago, and the streams themselves have almost completely diffused into space — making them hardly distinguishable from *isolated* or *sporadic* meteors.

The great showers are not difficult to remember; they are like series of colorful personalities.



Photograph by Henry Ferguson

A Perseid meteor trails off above Cassiopeia. An airplane also traveled across this 18 minute exposure of the northern sky. The photo was taken using a normal 50mm lens and Tri-X Pan film at ASA 400.

Quadrantids

The meteors of this first shower of the year radiate from the northeast corner of Bootes, so we might have expected them to be called the Bootids. But until about 100 years ago there was a constellation here called Quadrans Muralis, the "wall-quadrant" (an astronomical instrument). It is one of the many constellation names which have fallen into disuse.

The Quadrantid shower has a sharply defined peak of activity: It is above a quarter of its maximum strength for only about 14 hours. This means that the stream of particles is a narrow one — derived relatively recently from a small comet. The orbit has in fact been determined more exactly than that of any other stream. Its point of intersection with Earth's orbit (defined by the sun's longitude at the time) has been established to three decimals of a degree — and from this, the moment of the shower's peak is predicted to a fraction of an hour.

In 1975 the peak fell in the hours of darkness for North America between Jan. 3 and 4; in 1976 it will do so again. The moon spoiled that darkness in 1975, but in 1976 will be well out of the way.

Whenever the peak falls, we have to get up before dawn to see the best display. This is because the radiant is down low on the northern horizon till about midnight, rising slowly higher in the northeast toward dawn. It actually reaches its highest about 8:30 a.m., by which time the sun has risen for anyone south of England's latitude — so this shower is best for northern observers.

The number of about 100 meteors an hour usually seen at maximum is high — yet even this reliable shower can vary from 12 to 250 an hour at maximum. But the majority of the Quadrantids are faint — another indication that it is a young stream because small cometary particles seem to disperse earlier into space than large particles.

A curious discovery about this shower is that when *telescopic meteors* are counted (those that happen to cross the small field of a telescope while someone is looking through it), their peak is about seven hours *before* that of the ordinary *naked eye meteors*. When *photographic meteors* are counted, their peak is some hours *after* the visual one. Telescopic meteors can include much fainter ones than are seen with the naked eye, while photographic meteors include only the brighter ones. So the stream must be a lopsided one in which larger particles (making brighter flashes) tend to be traveling to one side. Perhaps if other showers were studied in the same way, something similar would be found occurring in them.

April Fireballs

During the last half of April, irregular numbers of very bright meteors have been seen coming from the southeastern sky before dawn. No precise radiant has been found; they approach from the broad area of Capricornus, Aquarius and Pegasus.

These fireballs often drop as meteorites, and perhaps they result from a broken up asteroid instead of a comet.

Lyrids

Lyrid meteors may be seen any night from April 19 to 24; they are above a quarter of their maximum in numbers for 2-1/2 days of this time, and the peak of the shower falls (in 1975 and 1976) after dawn on April 22.

The typical Lyrid is bright and leaves a shining train behind it for a few moments. But the true way to distinguish it from any other meteors seen around the same time is that its trail points back to near the dazzling white star Vega. Actually the radiant point is just southwest from Vega, on the border between Vega's little constellation of Lyra and the dim, sprawling constellation Hercules.

The Lyrid radiant is at its highest (right overhead for the southern United States, and not far off it for anyone in the midnorthern hemisphere) about the time that dawn twilight is beginning. In 1975, however, the moon was nearly full and did not set till nearly 3:00 a.m., so the good viewing was squeezed into about an hour between moonset and morning twilight. In 1976 the moon will be in its last quarter phase, and will thus spoil the whole "morning end of the night" — rising three hours after the radiant and shining not very far southward from it in the sky.

The Lyrids are following in the orbit of Thatcher's comet, which swung past us in 1861 (the year before the comet of the Perseids) and will not return till 2276.

Eta Aquarids

These could be called the May Aquarids, or the Swift Aquarids, or the Dawn Aquarids. Any of these would better help us remember the difference between this and another major stream called Aquarids which meet us later in summer.

Hardly any obvious stellar attractions exist in the portion of the sky known as the "ocean". The constellations in this region are generally associated with water and include Capricornus the sea goat, Aquarius the water carrier, Pisces and Piscis Austrinus (fish), and Cetus the whale. Eridanus, a stellar river, is also found in this region. Only Fomalhaut (the mouth of the lower fish in Pisces) and the urn of Aquarius shine bright above the horizon. Aquarius pours water in a starry cascade from his urn on the back of Capricornus. His body and the water from the urn are vague trickles of stars, but the urn itself is made of four fairly bright stars. The west or left star in this group is Eta Aquarii.

In late spring the sun is in Aries, so Aquarius (two constellations to the right) rises into the eastern sky only after midnight. Then occasional meteors are seen racing out into all parts of the sky from the east — as if Aquarius were giving his urn an annual shaking. This happens from about April 21 through May 12. At the peak around May 5 the predawn viewer may see a meteor about every four minutes. If the viewer were standing on the equator, he would see a higher average since the meteors' radiant is on the sky's equator and would climb more steeply above him. But even there the radiant would climb only halfway to the zenith before the sun rose to drown out the meteors. These meteors typically score very long lines across the night — lines which are preserved for a few seconds as glowing trails. We cannot help suspecting that

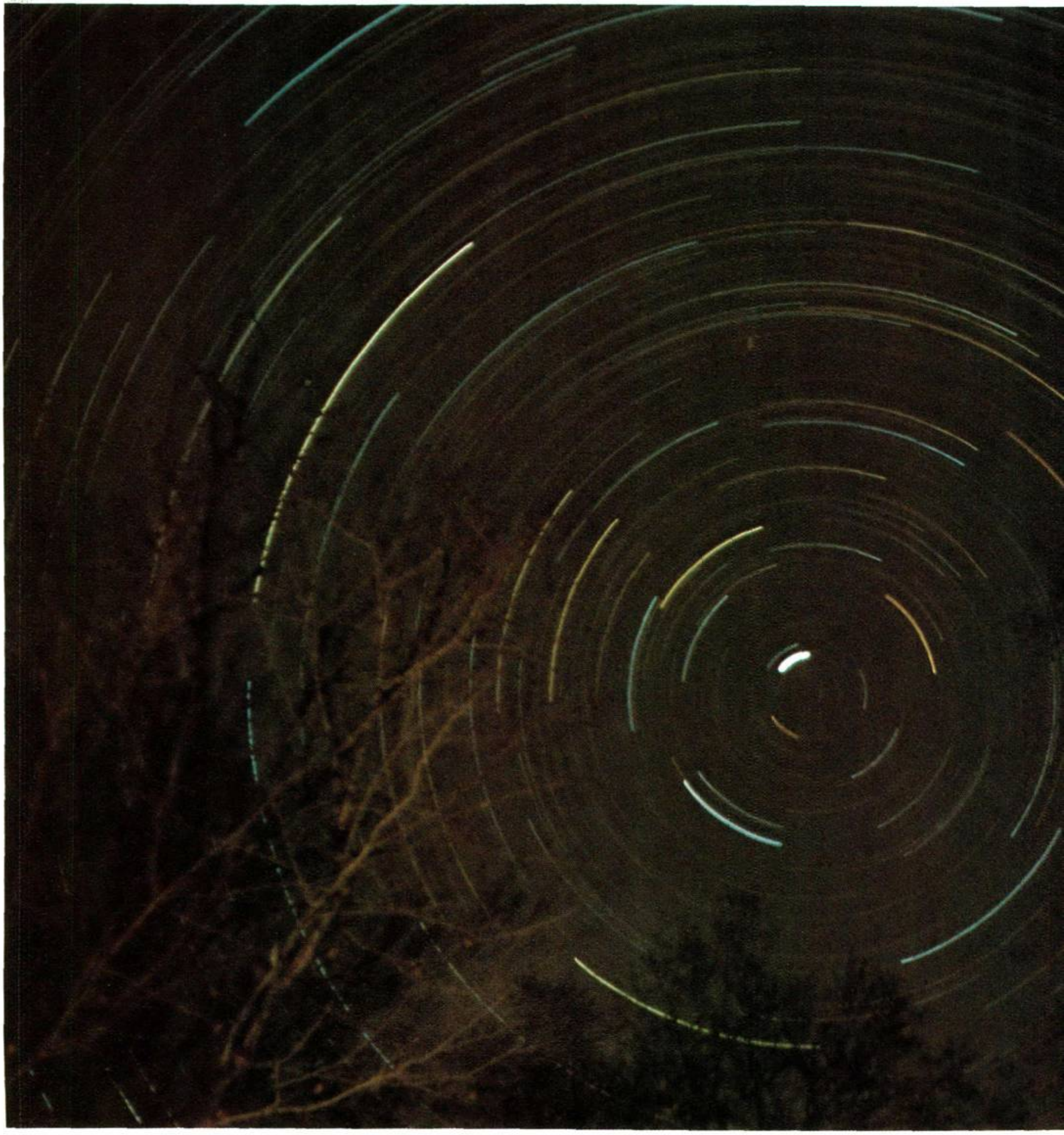
A long, brilliant red Perseid streaks to its doom in Earth's upper atmosphere. A 50mm f/2 lens captured the intruder on High Speed Ektachrome film at ASA 160.

Photograph by Peter Nowak

the urn contains something more fiery than water!

Why do the Eta Aquarids come at us only in the morning hours? And why are they so swift? The explanation of both is the same: Their orbit around the sun happens to be in the contrary direction to that of Earth. They are colliding with the forward side of Earth, and only when we are standing on that forward side — that is, in the morning — can we see them. They are hitting us with an apparent speed which is their own speed, plus ours.

The Eta Aquarids are thought to result from the orbit of Halley's comet (which has dominated cometary history throughout the brief history of man). The comet was first recorded in 467 B.C. by the Chinese; in 66 A.D. it "hung like a sword over Jerusalem", in 1066 it appeared as the Normans



An exceptionally bright meteor cuts across trails of circumpolar stars in this f/4, three hour exposure. The trails differ in color depending on the temperature of the associated star. A standard 35mm camera mounted on a tripod recorded the intruder on High Speed Ektachrome.

Photograph Copyright © by Marco Hellman

prepared to invade England. And in 1682 it was seen by Edmund Halley who finally deduced the periodic nature of comets from its motion.

When we look at the Eta Aquarid meteors, we are not looking at mere drops shaken from the urn of Aquarius; we are looking at some of the dust shaken from the feet of this famous comet as it runs its gigantic loop from the sun to Neptune.

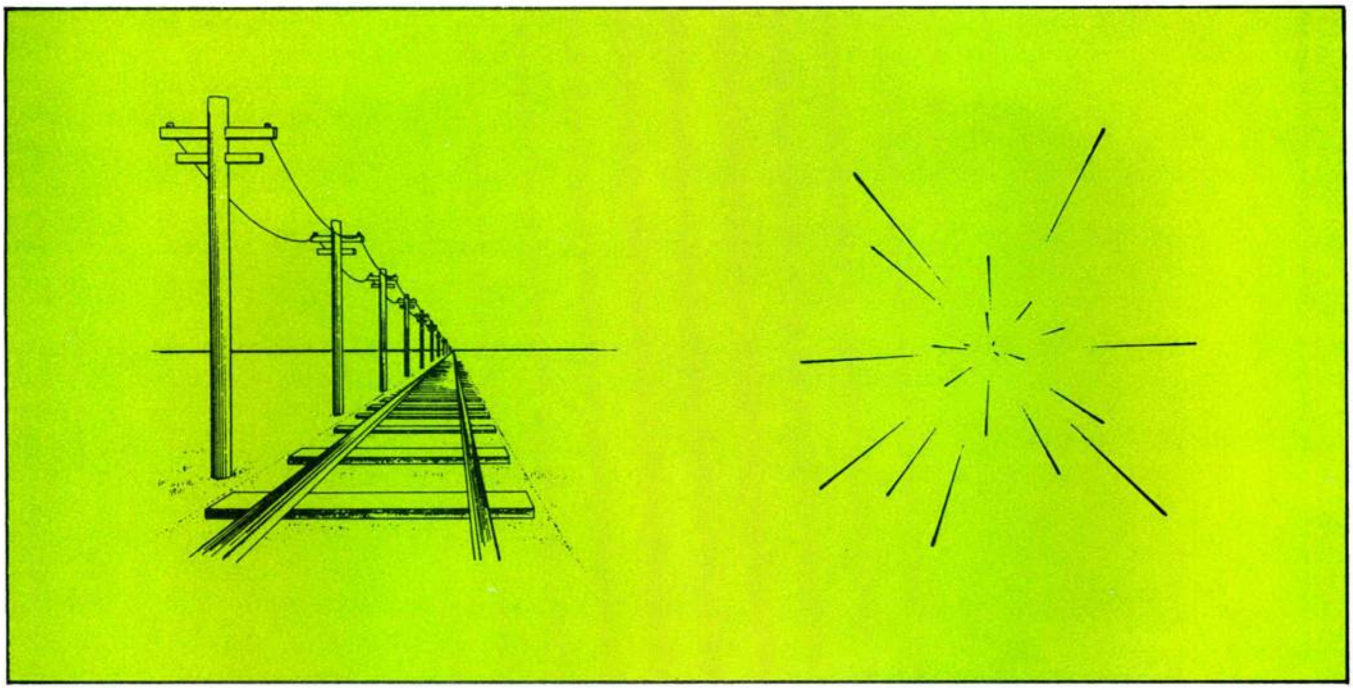
Delta Aquarids

It isn't easy to find any distinctive name for these Aquarids; they are not one stream but a broad, loose system of perhaps five streams. Only two should properly be called Delta Aquarids — the others being the North and South Iota Aquarids and the Piscis-Australids. Nor can we accurately call the whole system the July Aquarids, for its activity stretches feebly into August and even September.

This is an example of what happens to a meteor stream when it grows old. Even at the beginning, the particles could not have been moving in exactly the same orbit as their parent comet or they would not have separated from it. Their slight divergence accumulates with time. Meanwhile the sun is not the only body gravitationally controlling the particles' orbits; the planets are having their subtle effects on the stream. As the positions of the planets are constantly changing, the particles pass nearer to them on some revolutions than others — diverting parts of the stream, fanning it out, and splitting it. What was originally one stream diffuses into a cloud of minor streams and isolated particles in individual orbits, crossing Earth's orbit at yet more widely scattered times of the year and coming from more scattered directions until they are entirely stirred into the general haze of dust in the solar system.

The Delta Aquarids have not yet reached this unrecognizable stage, but at present it is difficult to keep related streams together and unrelated ones distinct. The strongest of the streams is the South Delta Aquarids, which actually radiate from near Delta Aquarii, a star in the vague "threads of water" pouring southward from Aquarius' urn. This shower yields 15 or 20 meteors per hour at its peak around July 28, and would yield perhaps 35 per hour if we watched it from 17 degrees south of the equator. The North Delta Aquarids show such similar characteristics that they are regarded as part of the same double stream, though their radiant is on the celestial equator in virtually the same spot as that of the Eta Aquarids of two months earlier. The Piscis-Australid meteors may well be a third branch of the same stream although their radiant is much farther south near the great star Fomalhaut. It only climbs up to 20 degrees above the horizon for U.S. observers, so that most meteors from it fall below our horizon. These three streams probably originate from one comet. But the two Iota Aquarid showers (which reach their maximum about Aug. 5) have different characteristics so that even though their radiants are near the Delta Aquarids, they derive from different comets.

By late July and early August we have traveled far around the curve of Earth's orbit from our position in early May. The direction we call "Aquarius" is no longer ahead in our flight but off to the right — outward from the sun — so that these July-August Aquarids are not colliding with us head-on, but are coming in sideways across our



Artwork by Victor Costanzo

Meteors traveling in parallel paths appear to diverge from their radiant just as parallel railroad tracks seem to diverge from a point at infinity. Meteor shower names are determined by the point in space they appear to radiate from. For example, the Leonids' radiant lies in the constellation Leo the lion.

orbit. Our own speed makes no difference one way or the other to their apparent speed. The medium speed at which we see them plow into our atmosphere is roughly their own natural speed in solar orbit.

Capricornids

At the same time of year there is another vague stream having at least two branches with radiants on the borders between the eastern parts of Capricornus and Aquarius. On Aug. 1 or 2 you may see from 5 to 20 yellow Capricornids an hour, some being fireballs. This year the last quarter moon will spoil the hours after midnight — the time when the Capricornid radiant is highest. This is a good excuse to do some meteor watching without going to the inconvenience of staying up well into the morning hours.

Perseids

This reliable shower mentioned earlier is also discussed in Gazer's Gazette, page 61.

Taurids

Here is another elderly stream that has fanned out into a broad river of substreams, rambling across our orbit for up to half the year.

The North Iota Aquarids (which begin appearing as early as July 15) have already been mentioned under the other very loose heading of Delta Aquarids — but they actually are thought to be a wandering branch of the Taurids. So are the Piscids, which are seen occasionally radiating from eastern Pisces in late September and early October.

Like the main Delta Aquarid shower, the main Taurid shower consists of a northern and a southern stream. As in the case of the Delta Aquarids, the southern is the stronger. Up to 15 meteors an hour can be seen in the first week of November; others straggle on till Dec. 15.

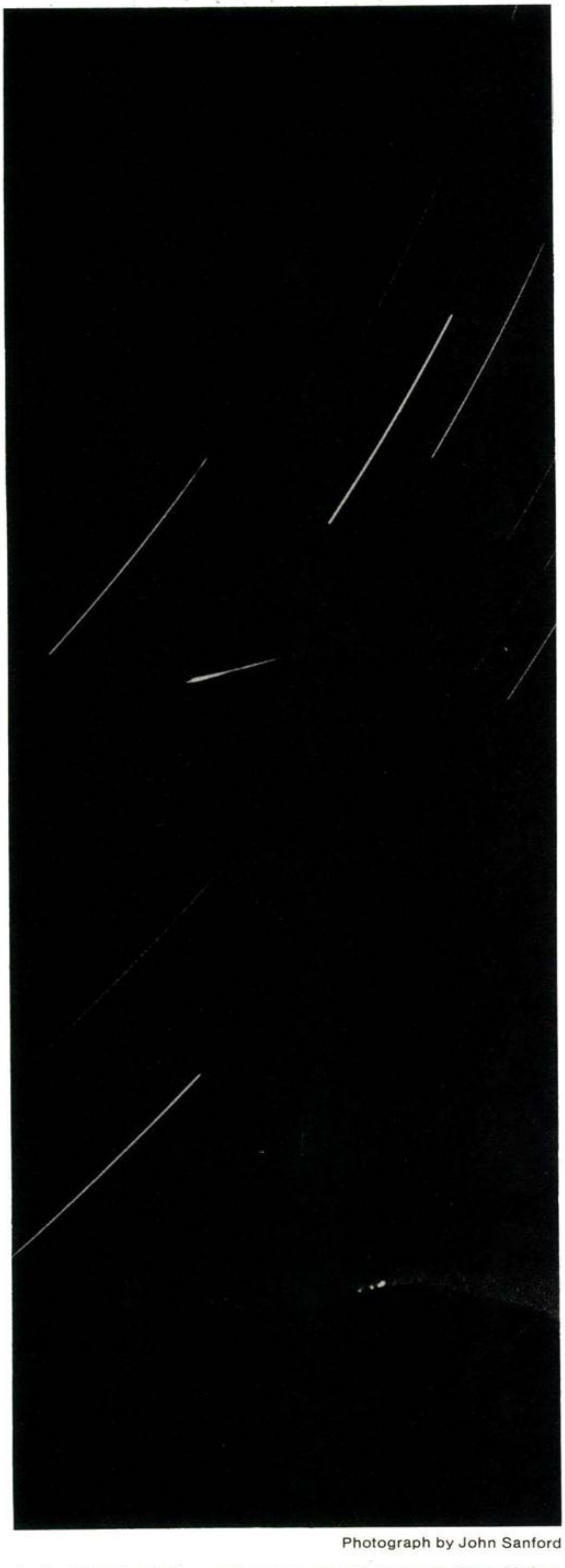
The two radiants lie just south of the Pleiades. So if in the fall you see a bright, slightly orange tinted meteor sliding rather lazily away from that famous little smudge of stars, you can feel sure it is a Taurid. All these substreams are debris from Encke's comet.

Draconids

These are also called the Giacobinids, because they are very clearly the children of comet Giacobini-Zinner.

The Draconids are still shedding from the comet. A dense swarm of particles travels close behind the comet, while the number spread far back along the orbit is small. This occurs in spite of the fact that the comet is in a short 6.6 year orbit — only twice that of comet Encke. The orbit, instead of being almost flat to the planets' orbits (like Encke's is), is turned almost perpendicularly to it. The comet rushes down from above the plane of the solar system to perihelion (the point where the comet is closest to the sun). This lies almost exactly on Earth's orbit, at the point Earth passes about every Oct. 9.

Conceivably, if the comet happened to come around to perihelion near Oct. 9, it could land on top of Earth. That is unlikely, since the orbits along which planets and comets journey are so vast in relation to their own size. However, at intervals of six or seven years, the comet passes



Photograph by John Sanford

A short but bright Leonid meteor blazes through Ursa Major. The Leonids are exceptionally fast, streaking into Earth's atmosphere at more than 35 miles per second. They are associated with comet Temple, first discovered in 1366.

through its perihelion in the months preceding Oct. 9. Then we arrive on that date, to find ourselves in the midst of its retinue of particles.

That happened in 1933 with the tremendous Draconid shower, when 20,000 meteors per hour were seen (or at least estimated). Two comet periods later, in 1946, astronomers realized that the comet was due to pass this place in Earth's orbit only 15 days before Oct. 9. We were not disappointed. In the southwest states, 7,200 per hour was the rate — even though the moon was full! But in the northeastern states, skies were clouded. During the war, it had been discovered that meteors make characteristic whistles on radio receivers; the great Draconid shower was recorded by the radio whistle technique even though it could not be seen because of clouds and the moon.

This year the moon will be a thin crescent and out of the way after 9:00 p.m., but it is not one of the years when the comet has recently passed. On the night of Oct. 9, we may see one or two meteors straggling two or more years behind the comet, and appearing to descend on us from the diamond of stars forming the head of Draco the dragon. All meteors called Draconids (and there are many minor showers with the same name besides this irregularly major one) are coming down into our orbit perpendicularly to the plane of the solar system. The point called the north pole of the ecliptic (in effect, the north pole of the solar system) is in Draco.

Orionids

Later in October, Earth meets a stream of meteors appearing to fly toward us from Orion's club.

Remember that since May, Earth's orbit has curved around greatly; we are now nearly halfway round the circle. The Eta Aquarids on May 5 came at us from almost dead ahead; now on Oct. 21, it is the Orionids that come at us from dead ahead, or slightly to the right of our direction of orbit.

When the curves made by the Eta Aquarids in May and the Orionids in October are drawn, they link up to form one curve. They are parts of the same permanent river of meteors following Halley's comet. In May we meet them on their way outward from their nearest approach to the sun, and in October we encounter the part of the meteor stream moving inward toward the sun. The orbit is in fact a *retrograde* one — moving opposite or contrary to our orbital direction of motion. That explains why both the Eta Aquarids and the Orionids hit our atmosphere very swiftly (their speed is 42 miles per second — slower only than the Leonids).

Another characteristic that the Orionids share with the Eta Aquarids is that they start burning up very high in the atmosphere — probably because they are of lightweight material. This means they come from the diffuse surface of the comet, and not its core.

Some Orionids are fireballs, but most are faint — so the shower is not especially good to photograph. The average hourly maximum to be seen in midnorthern latitudes is 25, although it varies from 10 to 70. Orion, now ahead of us in our journey around the sun, does not rise in the sky until 9:00 p.m., and the greatest number does not occur until just before dawn when Orion is overhead. But this year the moon will be just past full and in the sky all night — so we cannot expect to see many Orionids.

Andromedids or Bielids

A comet was discovered by an Austrian officer named Biela in 1826. It had (like Giacobini's comet and several others gravitationally influenced by Jupiter) a 6.6 year period, and upon returning in 1832 was spectacular enough to create a panic in France. In 1838 the comet began to be accompanied by a meteor shower, which at that time occurred in early December.

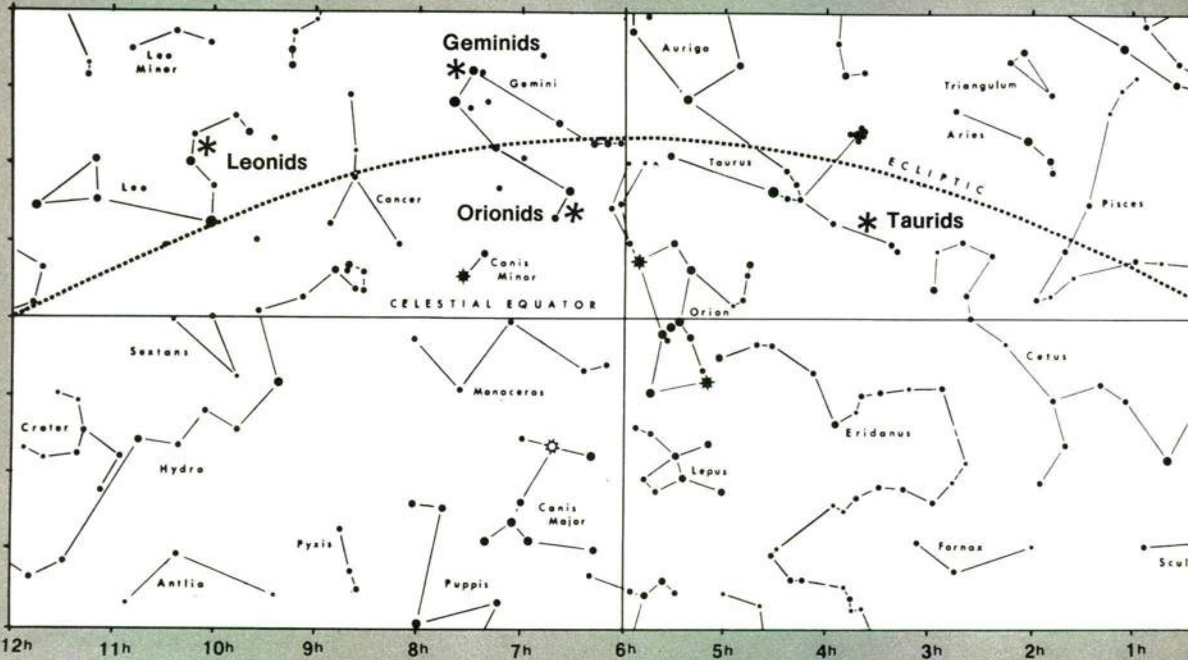
By 1845, people watching the comet in telescopes saw it become pear shaped and after a few days divide into two bright drops. The divided core became two comets, each possessing its own coma and tail. In 1852 the two comets reappeared — but by then had drifted apart by 1,500,000 miles.

Naturally, astronomers were eager to see what stage this phenomenon would reach in 1859 and 1866, but cloudy skies prevented them. In 1872 the skies were clear at the right moments, but the comet was not to be seen. Instead, in November of that year, 10,000 meteors per hour were seen raining upon us from the apparent direction of the constellation Andromeda. The world had seen a comet replaced by a meteor swarm!

On Nov. 27, 1886 — about the same time as that year's shower — an iron meteorite hit Earth at Mazapil in Mexico (about 250 miles southwest of Laredo), and was claimed as "really a piece of Biela's comet itself".

The great showers continued at six or seven year intervals until 1898. Because the stream's orbit passes Jupiter's strong gravitational field, the meteors have been fanned out so that nowadays a few of the meteors start appearing as early as the end of August and as far south as Pisces (where they confusingly overlap with those other Piscids that belong to the Taurid family). Through October, the radiant migrates northward until in November it reaches the site of the great Andromedid showers of earlier years. The date to wait for them is Nov. 14 (after 2:00 a.m. when the moon sets) — but you will be lucky if you see any more "pieces of Biela's comet". They will come softly and slowly because

MAJOR ANNUA



Shower	Date of Maximum	Radiant R.A.	Radiant Dec.	Maximum Hourly Rate
Quadrantids	January 3	15^h28^m	+50°	40
Lyrids	April 22	18^h16^m	+34°	15
Eta Aquarids	May 5	22^h24^m	00°	20
Delta Aquarids	July 29	22^h36^m	-17°	20
Perseids	August 12	03^h04^m	+58°	50

they are catching up with the traveling Earth from behind.

Leonids

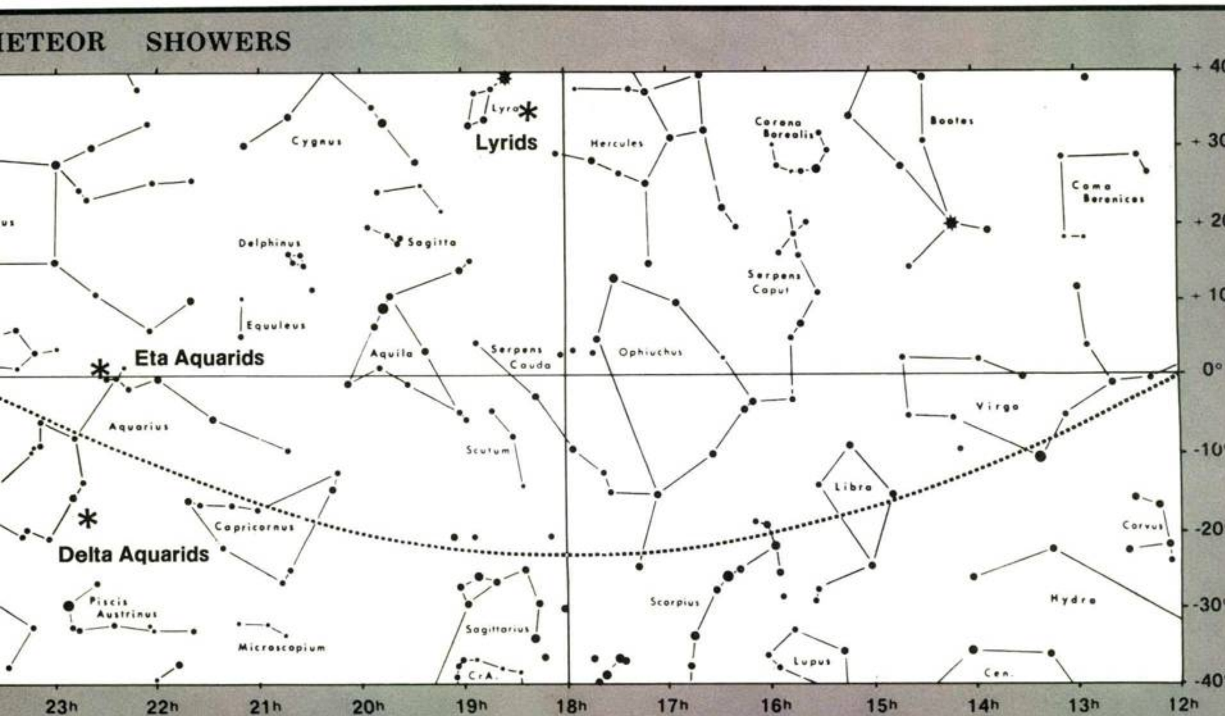
Like comet Giacobini-Zinner of the Draconids, comet Tempel-Tuttle (first seen in 1366) sweeps through a perihelion which is almost exactly on Earth's orbit. This comet, however, is in an orbit which is approximately flat to ours, and in the reverse direction. So when we meet its dusty trail on the night of Nov. 17-18, the particles in it collide with us at their maximum possible speed — 44 miles per second. This is so fast that none of them has ever been known to escape burning up entirely and reach the ground as a meteorite. If a meteor were traveling only a little faster than this, it would fly out of the solar system.

They come at us from Leo, which at this season is dead ahead of us in our path around the sun. This means that we have to be on the front of Earth to see them coming — that is, we must be up during the hours from midnight to dawn. Many are extremely bright and are tinged with green or blue because of their great speeds. About half leave luminous trails — some hanging in the air for up to eight minutes. The meteors begin to flow when they are still nearly 100 miles up because they, like the Orionids, are thin skimmings from the surface of their comet.

The comet's orbit goes out far enough so that it would just cast a loop round Uranus, if Uranus happened to be in that part of its own orbit. It has been theorized that Uranus *was* there in 126 A.D., and deflected the comet onto its orbit down among the inner planets.

The comet and particles take 33-1/4 years to travel around their orbit, and the particles are still mainly bunched up near the comet. Therefore, only in each 33rd or 34th year have great showers been seen — but they have been spectacular.

In 472 A.D. the shower was seen from Constantinople, then the capital of the Eastern Roman Empire. Arabs said 902 A.D. was the "Year of the Stars", as Leonid meteors whitened the night during which Ibrahim, king of Tunisia and Sicily, lay dying. In 1799, Alexander von Humboldt — one of the most versatile scientists who ever lived — watched the shower during his explorations in Venezuela. In 1833, literally overnight, the Leonids revealed the true nature of all meteor showers. First, they could not be falling stars; the eye can only see 3,000 stars, but 240,000 had "fallen"! More importantly, when eight or more appeared each


ETEOR SHOWERS
Lyra
Lyrids
Cygnus
Hercules
Corona Borealis
Bootes
Coma Berenices
Delphinus
Sagitta
Serpens Caput
Equuleus
Eta Aquarids
Aquila
Serpens Cauda
Ophiuchus
Virgo
Aquarius
Scutum
Libra
Corvus
Capricornus
Delta Aquarids
Scorpius
Hydra
Piscis Austrinus
Sagittarius
Microscopium
CrA.
Lupus
Cen.
+40°
+30°
+20°
+10°
0°
-10°
-20°
-30°
-40°
23h
22h
21h
20h
19h
18h
17h
16h
15h
14h
13h
12h

Shower	Date of Maximum	Radiant R.A.	Radiant Dec.	Maximum Hourly Rate
Orionids	October 21	06^h20^m	+15°	25
Taurids	November 4	03^h32^m	+14°	15
Andromedids	November 14	01^h40^m	+44°	5
Leonids	November 17	10^h08^m	+22°	10
Geminids	December 14	07^h32^m	+32°	50

second it was visually obvious that they were fanning out from a radiant in the head of Leo. This radiant was in the same place for all observers and remained so as the night wore on and the sky turned. This proved that the meteors were traveling parallel to each other from somewhere outside the atmosphere.

Great showers continued up to 1899 when the Leonids died down. Their orbit had been perturbed by Jupiter — as happens to most comets and meteors sooner or later — or the meteors were at last becoming more evenly and thinly spread along their orbit. The Leonids, like the Draconids and Andromedids, had become presumably just a minor stream.

But this was not so. In 1961 they began to revive, reaching up to 50 per hour by 1964 — with the periodic year coming round again in 1966. In the predawn hours of Nov. 17, 1966, the rate was estimated by some as 140 per second. That works out to 504,000 per hour!

This was the greatest meteor shower ever seen, at any rate in historical time. Who knows what comets, long dead, sowed yet greater showers into the skies of primitive men?

Meteors are so small and move so fast through the reaches of space that even in the 1966 shower, the particles were at least twenty miles apart.

The Leonids have not gone away; the great knot in the stream will not come round again till 1999. Meanwhile in 1972 and 1974, up to 40 per hour were seen. This year, the nearly full moon will go down only just before the sun comes up (and as Leo is at its highest). It may not be worthwhile to get up early on Nov. 18 — and yet, should we chance being asleep the next time Leo mightily shakes his mane?

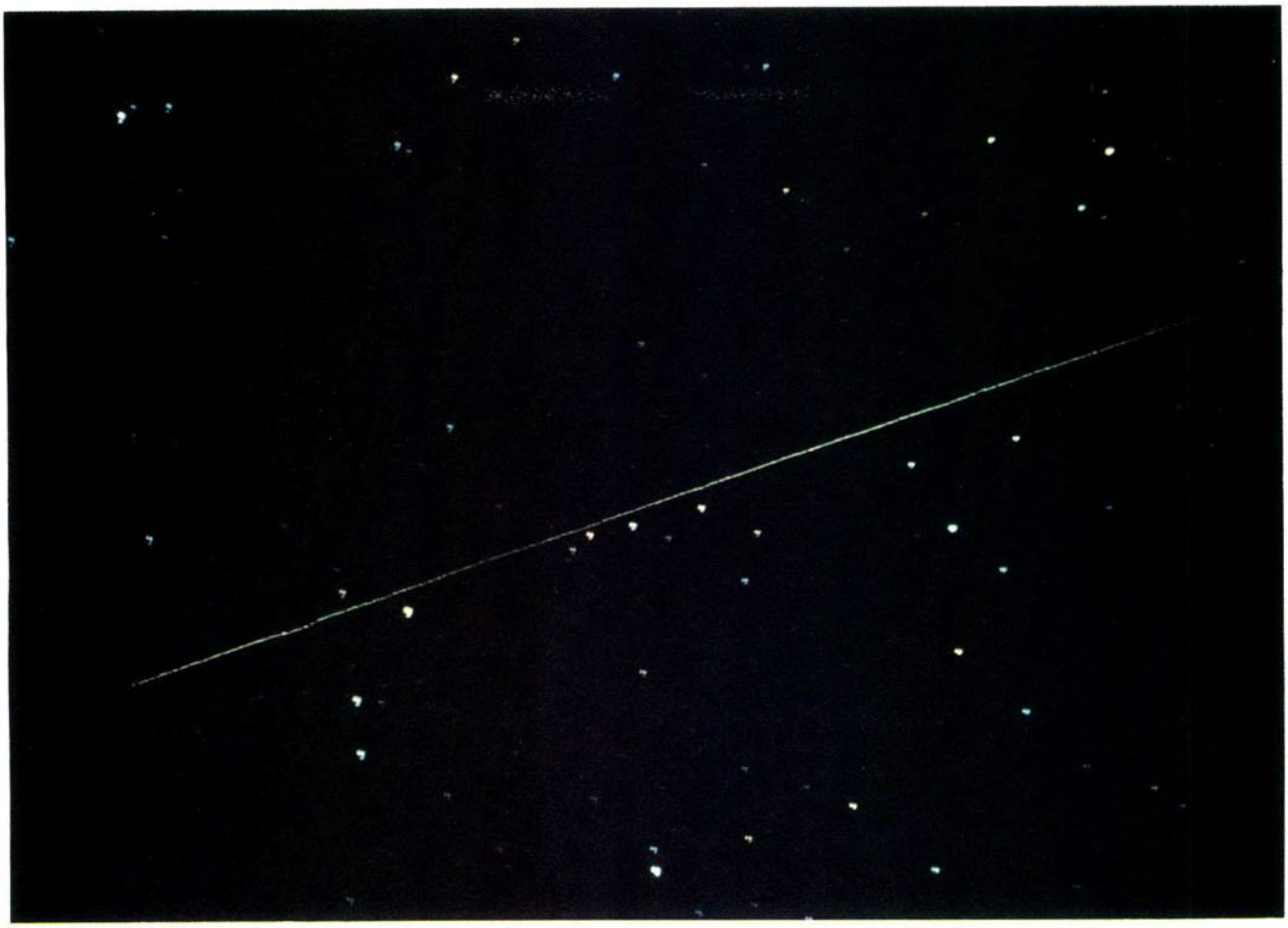
Geminids

This competes with the Orionids as our next most dependable shower following the Perseids. Usually 50 and sometimes 80 meteors an hour appear on the night of Dec. 14-15. They radiate from Castor, the dimmer of the twin stars in Gemini.

Since Gemini is now off to the right of us as we move along our orbit — roughly on the opposite side of us from the sun — it is up in the sky all night, being highest not long after midnight. Because the meteors are moving in across our orbit — not chasing us from behind or colliding with us from the front — they are of medium apparent

Photograph by Gordon Moeller

A Cygnid courses its way through a rich star field on its way to oblivion. The object reached an estimated peak magnitude of -2 as it streaked into the atmosphere on the morning of Aug. 13, 1974.



Photograph by James Elwell

The skies over Utah yield a long Perseid colliding with Earth's atmosphere. Perseid meteors are noted for high velocities (above 40 miles per second) and long trails. In this 30 second exposure, Cassiopeia appears in the background.

speed (about 23 miles per second). They are bright and white, but leave few visible trails. They are four times denser than most other meteors, and form jagged or divided paths. Surprisingly, their parent comet has not been found despite the fact that such a rich stream ought still to have one — one that is unusually close to Earth and the sun.

The steady numbers of the Geminids and the convenient placing of their radiant in our sky do not help us if the moon is full. The Orionids, Leonids and Geminids occur 27 days apart, and the length of the cycle from full moon to full moon is about 29 days. Unfortunately, the dates of full moon this year in October, November and December fall just before the Orionids, almost on top of the Leonids, and just after the Geminids. For the ordinary person who sky gazes only in the evening, it is better when full moon occurs *before* the event because he can hope to squeeze a little watching in between sunset and moonrise (this effect is not enough to save the Orionids this year). But for the dedicated meteor watcher, it is better when full moon follows the shower by a few days because then the moon at least gets out of the way during the predawn hours, when meteors of most types are more abundant.

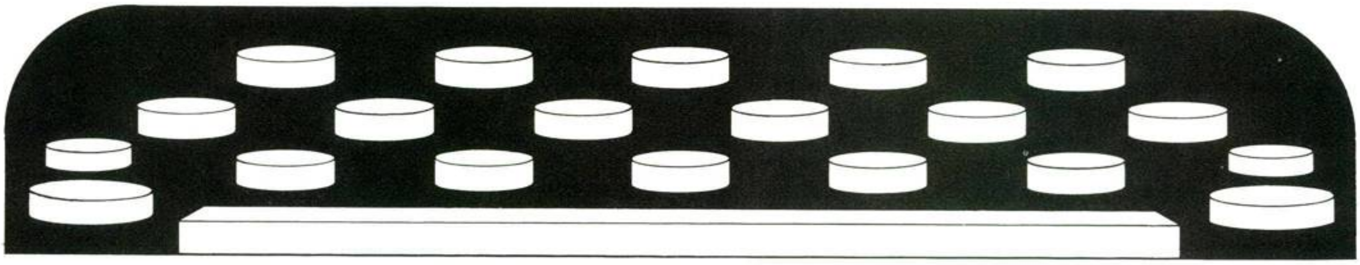
Thus, the morning of either Dec. 14 (when the moon sets at 3:00 a.m.) or Dec. 15 (when the moon sets at 4:00 a.m.) promises the best chance for watching the Geminids this year. The peak is predicted to occur in the intervening daylight for North America; the same time is in darkness for Europe.

Ursids

The year's last notable shower occurs on the night of Dec. 22-23, when the moon has just passed its full stage and is in the sky all night from about 8:00 p.m. onward. This is unfortunate because the Ursids "badly need observing", according to the British Astronomical Association.

That observers have neglected the Ursids is not surprising. Everything about them is wintery. They come at the winter solstice, and are best seen by polar bears since they come from near the celestial north pole. The meteors are sometimes called the Umids, in an attempt (rather unsuccessful) to make clear that their radiant is in Ursa Minor, not Ursa Major. The radiant is actually near Kochab, or Beta Ursae Minoris, the only brightish star in our polar constellation other than Polaris.

Keep the Ursids in mind and brave the cold — in 1976. This year, enjoy Christmas instead!



IN FOCUS

To Steven Soter and Carl Sagan:

by David R. Saunders

Last month, Steven Soter and Carl Sagan offered two counterarguments relating to Terence Dickinson's article, "The Zeta Reticuli Incident" (ASTRONOMY, December 1974).

Their first argument was to observe that the inclusion of connecting lines in certain maps "is what a lawyer would call 'leading the witness'." This was used as the minor premise in a syllogism for which the major premise was never stated. Whether we should consider "leading the witness" a sin or not will depend on how we conceive the purpose of the original article. The implied analogy between ASTRONOMY magazine and a court of law is tenuous at best; an expository article written for a nonprofessional audience is entitled, in my opinion, to do all it can to facilitate communication — assuming that the underlying message is honest. Much of what we call formal education is really little more than "leading the witness", and no one who accepts the educational goals objects very strongly to this process. In this context, we may also observe that Soter's and Sagan's first argument provides another illustrative example of "leading the witness"; the argument attacks procedure, not substance — and serves only to blunt the reader's possible criticism of the forthcoming second argument. This paragraph may also be construed as an effort to lead the witness. Once we have been sensitized to the possibilities, none of us needs to be further misled!

The second argument offered by Soter and Sagan does attack substance. Indeed, the editorial decision to publish the original article was a responsible decision only if the issues raised by this second line of possible argument were fully considered. Whenever a statistical inference is made from selected data, it is crucial to determine the strenuousness of that selection and then to appropriately discount the apparent clarity of the inference. By raising the issue of the possible effects of selection, Soter and Sagan are right on target. However, by failing to treat the matter with quantitative objectivity (by failing to weigh the evidence in each direction numerically, for example), they might easily perform a net disservice.

In some situations, the weight of the appropriate discount will suffice to cancel the clarity of a proposed inference — and we will properly dismiss the proposal as a mere capitalization on chance, or a lucky outcome. (It is abundantly clear that Soter and Sagan regard the star map results as just such a fortuitous outcome.) In some other situations, the weight of the appropriate discount may be fully applied without accounting for the clarity of the inference, and we will prefer to retain the inference as a potentially valid discovery. For example, if I proposed to infer from four consecutive coin tosses observed as heads that the coin would always yield heads, you would properly dismiss this proposal as unwarranted by the data. However, if I proposed exactly the same inference based on 40 similar consecutive observations of heads, you would almost certainly accept the inference and begin looking with me for a more systematic explanation of the data. The crucial difference here is the purely quantitative distinction between 4 and 40; the two situations are otherwise identical and cannot be distinguished by any purely qualitative argument.

When Soter and Sagan use phrases such as "some subset that resembles", "free also to select the vantage point", "simple matter to optimize", and "freedom to contrive a resemblance", they are speaking qualitatively about matters that should (and can) be treated quantitatively. Being based only on this level of argument, Soter's and Sagan's conclusions can only be regarded as inconclusive.

A complete quantitative examination of this problem will require the numerical estimation of at least three factors, and their expression in a uniform metric so that we can see which way the weight of the evidence is leaning. The most convenient common metric will be that of "bits of information", which is equivalent to counting consecutive heads in the previous example.

One key factor is the degree of resemblance between the Hill map and the optimally similar computer-drawn map. Precisely how many consecutive heads is this resemblance equivalent to? A second key factor is the precise size of the population of stars from which the computer was allowed to make its selection. And a third key factor is the precise dimensionality of the space in which the computer was free to choose the best vantage point. If the first factor exceeds the sum of the other two by a sufficient margin, we are justified in insisting on a systematic explanation for the data.

The third factor is the easiest to deal with. The dimensionality of the vantage-point space is not more than three. A property of the metric system for weighing evidence is that each independent dimension of freedom leads us to expect the equivalent of one more consecutive head in the observed data. Three dimensions of freedom are worth exactly 3.0 bits. In the end, even three bits will be seen as relatively minor.

The second factor might be much larger than this, and deserve relatively more discussion. The appropriate discount for this selection will be $\log_2 C$, where C is the number of distinct combinations of stars "available" to the computer. If we were to agree that C must represent the possible combinations of 46 stars taken 14 at a time, then $\log_2 C$ would be 37.8 bits; this would be far more than enough to kill the proposed inference. However, not all these combinations are equally plausible. We really should consider only combinations that are adjacent to one another and to the sun, but it is awkward to try to specify exactly which combinations these are.

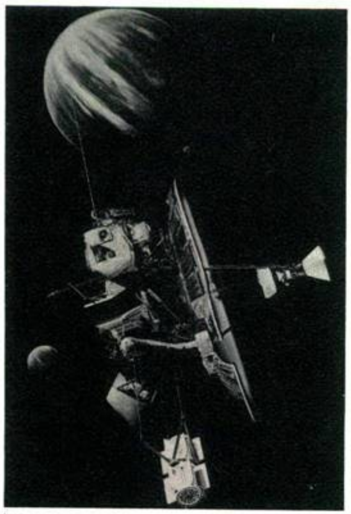
The really exciting moment in working with these data came with the realization that in the real universe, our sun belongs to a closed cluster together with just six of the other admissible stars — Tau Ceti, 82 Eridani, Zeta Tucanae, Alpha Mensae, and Zeta 1 and Zeta 2 Reticuli. The real configuration of interstellar distances is such that an explorer starting from *any* of the seven should visit *all* of them before venturing outside. If the Hill map is assumed to include the sun, then it should include the other members of this cluster within an unbroken network of connections, and the other connected stars should be relatively adjacent in the real universe.

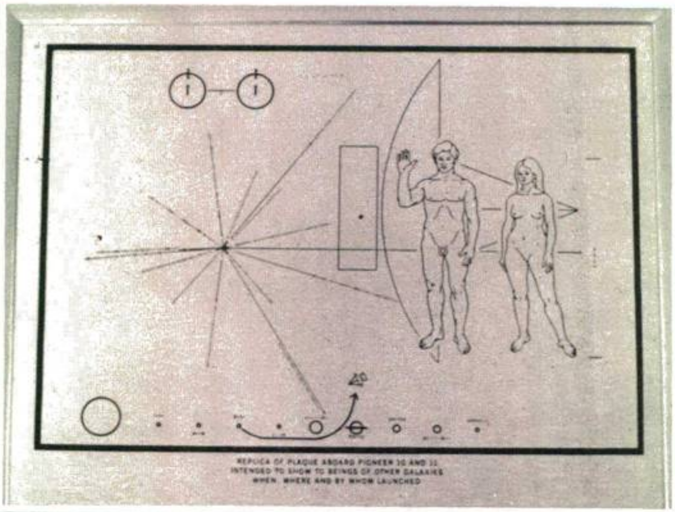
Zeta Reticuli occupies a central position in all of the relatively few combinations that now remain plausible. However, in my opinion, the adjacency criteria do leave some remnant ambiguity concerning the combination of real stars to be matched against the Hill map — but only with respect to the region farthest from the sun. The stars in the closed cluster and those in the chain leading to Gliese 67 must be included, as well as Gliese 86 and two others from a set of five candidates. $\log_2 C$ for this remnant selection is 3.9 bits. We must also notice that the constraint that Zeta Tucanae be occulted by Zeta Reticuli reduces the dimensionality of the vantage-point space from 3.0 to 1.0. Thus, the sum of factors two and three is now estimated as only 4.9 bits.

The first factor is also awkward to evaluate — simply because there is no standard statistical technique for comparing points on two maps. Using an approximation based on rank-order correlation, I've guessed that the number we seek here is between 11 and 16. (This is the result cited by Dickinson on page 15 of the original article.) Deducting the second and third factors, this rough analysis leaves us with an empirical result whose net meaning is equivalent to observing at least 6 to 11 consecutive heads. (I say "at least", because there are other factors contributing to the total picture — not discussed either by Dickinson or by Soter and Sagan — that could be adduced to enhance this figure. For example, the computed vantage point is in good agreement with Betty Hill's reported position when observing the map, and the coordinate system implicit in the boundaries of the map is in good agreement with a natural galactic coordinate system. Neither have we discussed any quantitative use of the connections drawn on the Hill map, which were put there in advance of any of these analyses.)

In the final interpretation, it will always be possible to argue that 5 or 10 or even 15 bits of remarkable information simply isn't enough. However, this is a matter for each of us to decide independently. In deciding this matter, it is more important that we be consistent with ourselves (as we review a large number of uncertain interpretations of data that we have made) than that we be in agreement with some external authority. I do believe, though, that relatively few individuals will continue a coin-tossing match in which their total experience is equivalent to even six consecutive losses. In scientific matters, my own standard is that I'm interested in any result that has five or more bits of information supporting it — though I prefer not to stick my neck out publicly on the basis of less than 10. Adhering to this standard, I continue to find the star map results exceedingly interesting.

Dr. David R. Saunders is a Research Associate at the University of Chicago's Industrial Relations Center.

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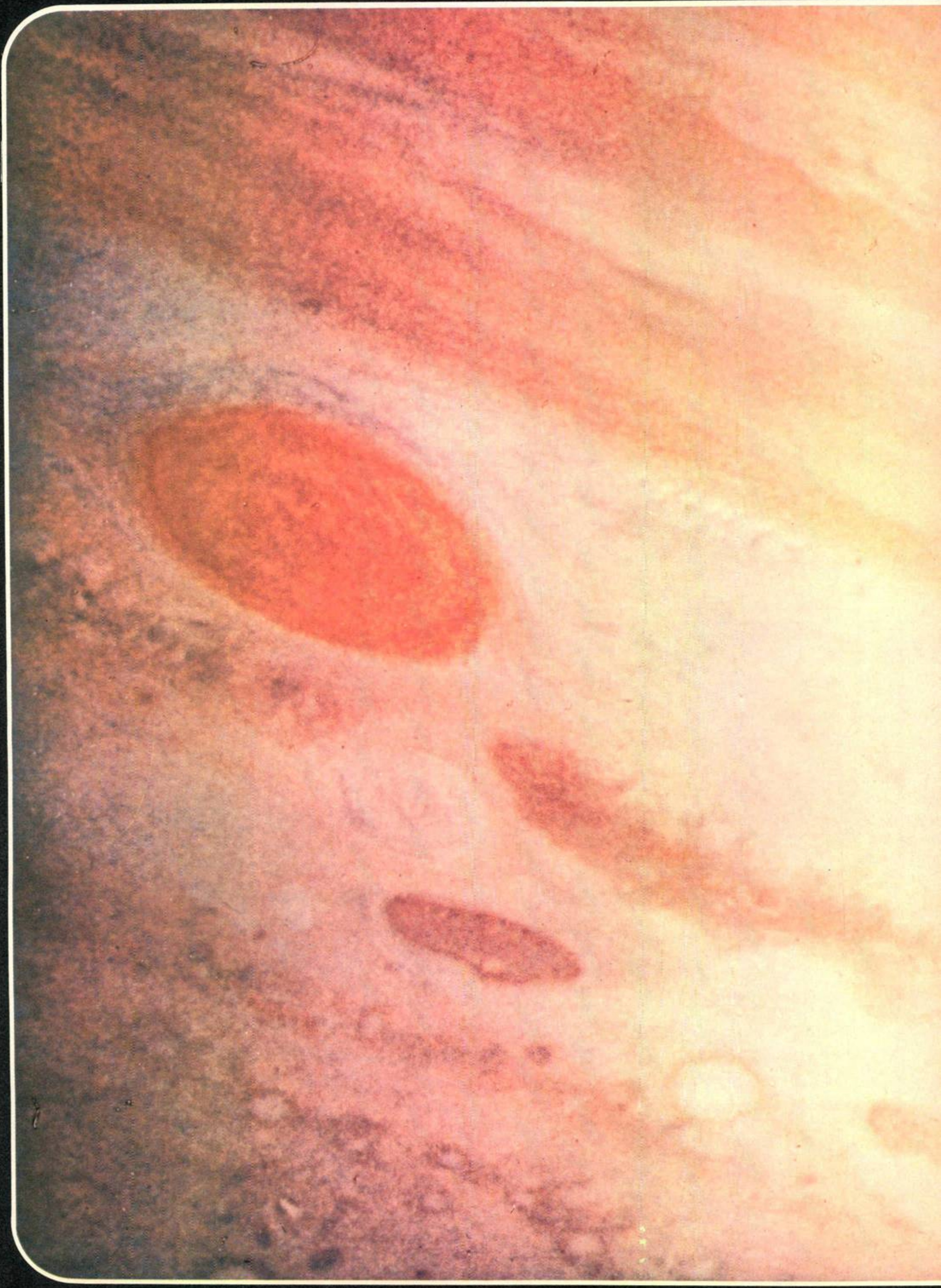

The Great Red Spot

The most colossal storm ever seen by man has been raging on the planet Jupiter for at least three centuries and shows no signs of abating. The storm, a rusty colored oval that astronomers long ago unimaginatively dubbed the Great Red Spot, has recently been revealed in exquisite detail by special processing of photographs taken last December when Pioneer 11 hurtled to within 29,000 miles of the solar system's largest planet.

Large enough to swallow three Earths, the spot towers five miles above the main Jovian cloud decks. The entire visible surface of Jupiter is a maelstrom of swirling brown and yellow clouds swept into vast belts and zones that give the planet a striped appearance. The cloud systems adjacent to the spot seem to impart a counterclockwise spin to the giant oval — something like a ball bearing between two moving surfaces.

The white clouds north of the spot flow from right to left in the picture, while the darker material below the spot moves from left to right. The triangular regions on either end of the spot appear to be areas where these two streams converge to flow side-by-side in opposite directions.

Analysis of details visible within the spot seem to confirm counterclockwise circulation there. Theory suggests that the spot should rotate due to the flow in opposite directions of cloud streams north and south of it.

Why is the spot red? Nothing else on the planet seems to have its vivid hue. Although the spot does vary from dull brown to a pinkish hue, it is by far the most prominent single feature on the planet — and the most enduring.

Since the spot is an oversized storm cell, scientists theorize it is "fed" from atmospheric sources far below the normal cloud levels. At such depths, phosphine (PH_3) may be abundant; upon its exposure to the sun once it gets to the top levels of the spot, the phosphine would react chemically with other abundant elements producing a red phosphorous crystal.

This view is the finest picture of Jupiter's Great Red Spot ever obtained. Pioneer 11 was 338,000 miles from the giant planet when the photo was taken on Dec. 2, 1974. Months of painstaking image reconstruction were necessary to reveal the detail seen here.

NASA Photograph

Other researchers say this process is unlikely and suggest that ammonia polysulphide (a yellow gas that turns red with time) is responsible for the spot's hue. As yet there is no direct information to completely explain the color. However, the other Jovian clouds are now well analyzed. The yellow and white clouds are billowy layers of ammonia crystals, while the darker brown belts are ammonia hydrosulfide crystals at a lower level in the atmosphere. Below the clouds, a layer of water ice clouds — perhaps like Earth's — is suspected, and below that suspended water droplets in a mixture of methane and ammonia gas is theorized.

Strung out along the boundary between the white south tropical zone, containing the spot, and the brown belt north of it, is a series of small, white cloud puffs. (The puffs are only relatively small, typically about the size of Ohio.) The puffs may be an example of flow instability between the zone and belt, where cloud currents are fastest relative to the planet.

The white oval below the right end of the Great Red Spot is one of three nearly identical features which are usually 120 degrees apart around Jupiter, and have been observed for 30 years. The oval's position relative to the Red Spot changes with time due to a different rate of flow in the cloud current which contains it. New details of the white oval in this picture — such as the circular "eye" in its center — strongly suggest rotational motion.

Below the Red Spot, a stream of brownish cloud material seems to be interrupted in the region between the spot and the oval. This produces a noticeable "feathering" in the dark belt to the right of the spot. This interaction among spot, oval and belt appears to be one of the first examples seen of transfer of mass between the belts and zones — something predicted by theories on Jovian meteorology.

This outstanding photograph, a testimony to the success of the Pioneer missions, probably marks the last spectacular spacecraft portrait of Jupiter until 1979 when Mariners 11 and 12 will swing by the planet (see "Missions to the Giant Planets", February 1975). In the meantime, scientists continue to sort out the enigmas of a planet unlike Earth in almost every respect.

DECEMBER STAR DOME
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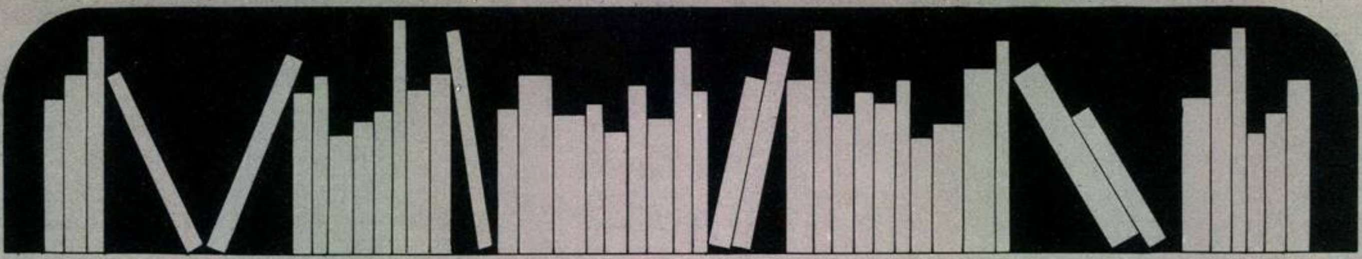

The Galactic Club: Intelligent Life in Outer Space
by RONALD N. BRACEWELL

141 pages, hardcover. $6.95 *
W. H. Freeman and Company (1975)

Most discussions about the possibilities of other intelligent life in the universe often tend to degenerate into the "one percent" game. If only one percent of all stars have planets, and one percent of planets lie in habitable temperature zones, and if only one percent of these planets develop life, and if one percent of the life leads to intelligence, then we are left with many such civilizations in every galaxy. The question becomes one of finding traces of them.

In reality, the odds of any of the above events may range from 100 percent certainty to zero percent impossibility, and other factors such as large natural satellites or mutation rates must also be considered. Only recently have astronomers, biochemists and geologists been able to put quantitative values on their guesses. And only recently have the technological questions of interstellar communication been similarly quantified. These are the themes of Bracewell's entertaining and thought-provoking book. The far-out ideas are fittingly matched with a selection of bizarre and exotic illustrations.

Just what are the odds of other planets having life on them? The author discusses this topic first, and admits that the possibility might be zero. This would lead to a very short book — while "the opposite view leads to interesting trains of thought."

Along the way, Bracewell asks some important questions. Is man unique? Should we talk to "them", and how? What do you say to a nonhuman? The answers involve discussions of Ozma, Arecibo, Cyclops, and politics — as well as speculations on the density and lifetimes of advanced galactic civilizations.

Some people think we have been visited already, but in two special chapters Bracewell demolishes the theories of Velikovsky and Von Daniken as "a romanticist's fiction". But having ventured into such controversies, the author pulls back from the abyss and fails to even mention that some people think we are still being visited by spaceships from other planets. Presumably the author ignores UFOs because he doesn't have a clever explanation for them.

The book is so good that minor omissions are all the more glaring. In discussing interstellar messenger probes, Bracewell does not talk about the delayed radio echoes received in Europe a few decades ago which some analysts have decoded into a star map. Nor does he admit that some science fiction writers were seriously examining the question of interstellar communications decades before "real" scientists discovered the problem. But these objections do not seriously detract from an excellent book on a fascinating topic.

* *Also available in paperback for $3.95.*

* * *

Highlights in Astronomy
by FRED HOYLE

179 pages, hardcover, $10.00 *
W. H. Freeman and Company (1975)

Books by famous authors always promise new insights, but this one is a severe disappointment. It suffers grievously from the aimless direction of the author, who does not seem to be able to decide for whom he is writing. At one point he devotes half a page to explain how a circle has 360 degrees; elsewhere he provides several pages of structural details on classification of varieties of galactic types.

Most likely, the text is aimed at young readers or laymen — and to whet their interest Hoyle assembles an impressive collection of illustrations and photographs. The book is visually stunning.

Unfortunately, the pleasure ends with the pictures. The best people to see this book are those too young to read. In the first chapter we are told why it is nice to have as much gravity as we do (otherwise "birds would be better placed in relation to the whole of evolution"); why plate tectonics are really "an advantage to human life", and why the sky is blue. Although Hoyle attempts to switch his measurements to the international metric system, feet and cubic inches keep popping up. The author even invents a new astronomical unit of time called the *human generation* (defined according to Hoyle and nobody else as 45 to 50 years), and goes on to express the age of Earth and the universe in terms of this absolutely valueless unit.

If the book is indeed aimed at novice readers, the author tries to pull a fast one on them when he discusses the redshift. This effect and its position in the steady state and big bang cosmological theories is well-known to students of astronomy, but Hoyle does a big disservice to his innocent audience when he attributes the redshift solely to the increase in mass of hydrogen atoms rather than to an expanding universe. Both theories have believers — but an honest writer should have at least mentioned the existence of the other theory. This is scientific partisanship at its worst.

The book also needs a better index and a better proofreader. It needs some strict editing of irrelevant anecdotes and asides which might have been charming in person but are only distracting and puzzling in print. Much of the text is excellent, but the overall impression is that of a quick patchwork job. Not enough time was taken in the writing of this book — and it shows.

* *Also available in paperback for $5.50.*

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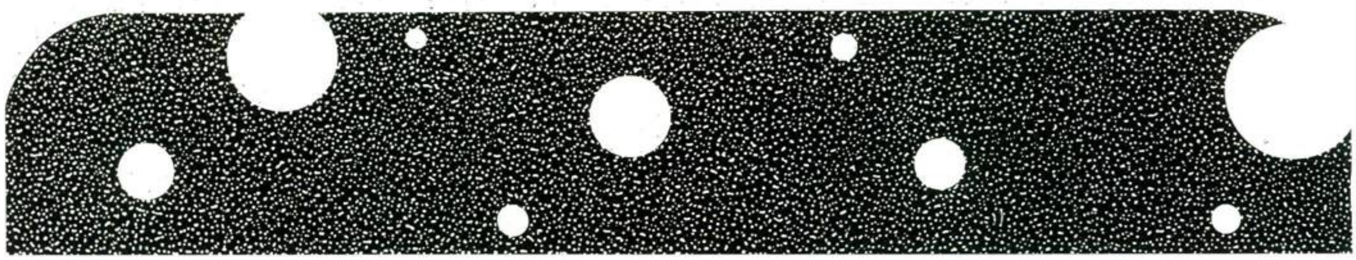


STELLAR FRONTIERS

Faster Than Light?

by

Gerrit L. Verschuur

A few years ago a team of astronomers discovered what appeared to be individual parts of quasars traveling away from each other at speeds greater than that of light. Since Einstein's laws of relativity state that matter cannot travel faster than light, this discovery caused a furor. The only things that can travel faster than light are hypothetical particles dubbed *tachyons*. But tachyons — if they exist — can never slow down enough to become observable; they too find the speed of light a barrier, because they can't get below it.

Quasars are strange starlike objects which emit strong radio signals and photographically appear bluer than most normal stars. They dwell outside our Milky Way galaxy at distances of billions of light-years. Distance estimates are based on the observations of the light from the quasars which suggest that they are moving away from us at enormous speeds. This so-called *redshift* of light can be interpreted as a measure of distance according to current concepts of an expanding universe (see "The Cosmic Bomb", April 1975).

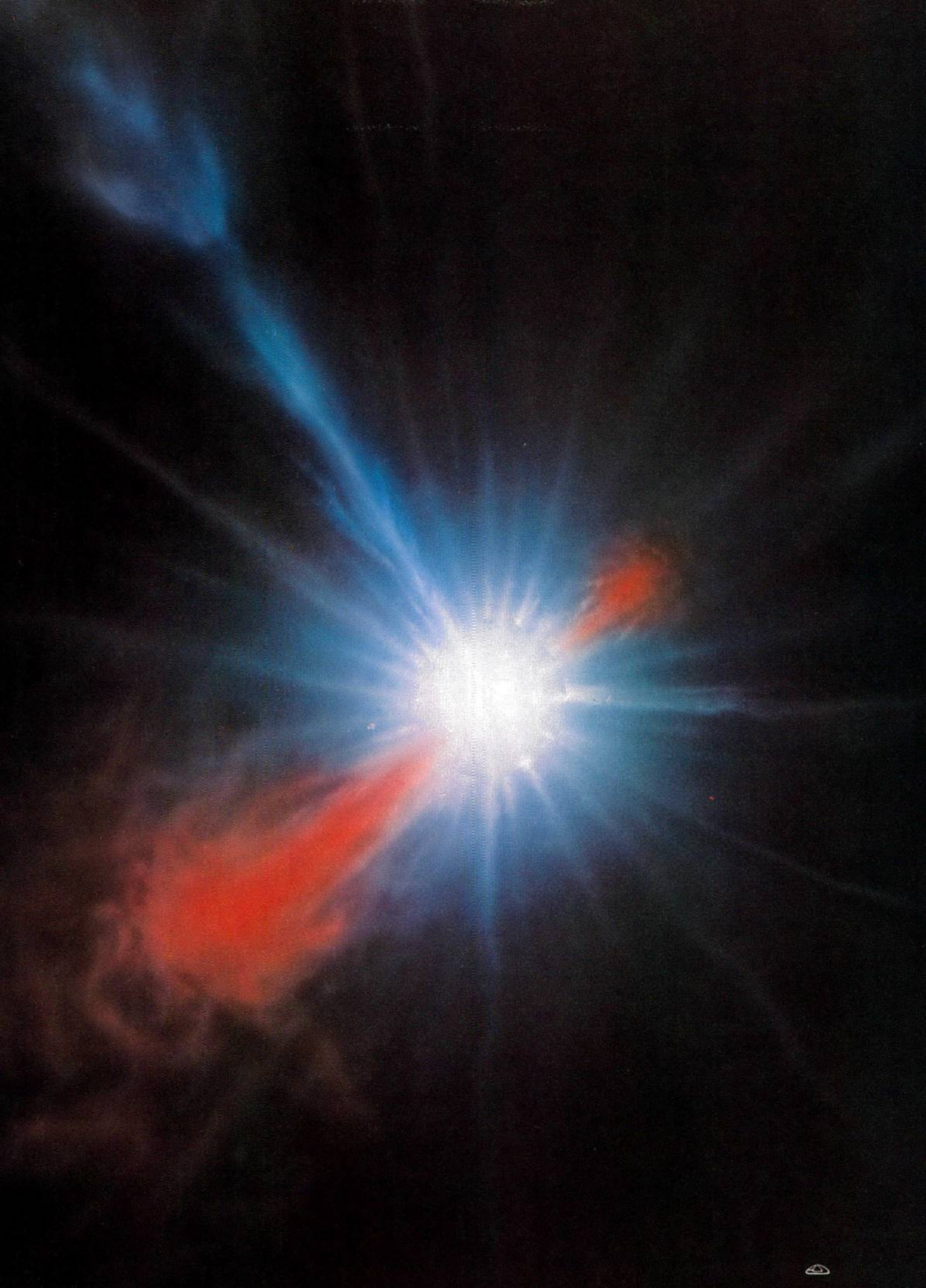
The quasar known as 3C273 is a prominent character in the faster-than-light story. One of the first discovered quasars, it looks very much like a bright star except for a jet of luminous material protruding from it. The jet was probably explosively thrown out of the quasar's central regions. In 1963, 3C273's radio signals were detected coming from both the core of the starlike object as well as from the jet itself — these two being separated by about 20 seconds of arc. Since the distance to 3C273 is estimated at three billion light-years (based on its redshift), the jet must be about 300,000 light-years long — the typical distance between galaxies.

Recently, closer looks at 3C273 have shown that the radio source inside the quasar (as opposed to the source coinciding with the jet) was more complex than previously thought. The core of 3C273 contains at least two small sources — each a light-year or so across and separated by the same amount of space. The original radio observations did not have sufficient accuracy for astronomers to be certain the core source wasn't more complicated, perhaps consisting of three or even four parts. However, if a simple double source was assumed, then radio measurements made over six months seemed to show that the two members of the double had apparently moved apart. Subsequent calculations revealed that the two components were flying apart at a speed exceeding that of light! Several other faster-than-light radio sources have since been observed.

Are there ways to create the illusion that parts of a quasar are traveling faster than light? Perhaps elements of the radio source — each flashing on and off independently — could be lined up in such a way that the sequential flashing on of one part after another part would lead us to think that we

Within a quasar's bright center, two gigantic regions of intense radio energy fly apart at unbelievable speeds — because, by current estimates, each energy "blob" is hurtling through space at several times the speed of light. Are these radio sources actually breaking laws of modern physics, or does their strange behavior result from an illusion?

Artwork by Adolf Schaller



were seeing a single radio source traveling very fast.

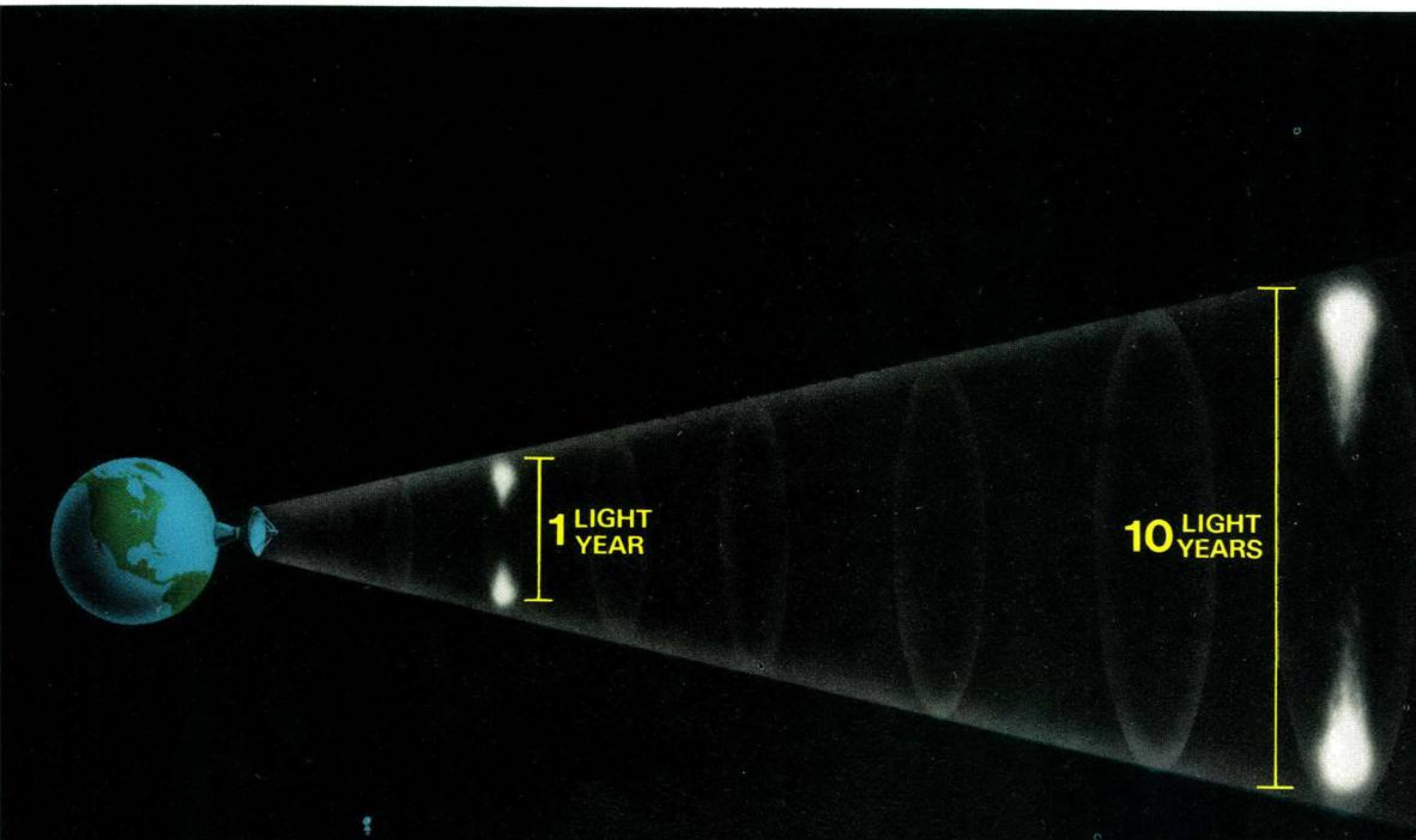
Imagine that you see the headlights of two cars a certain distance apart traveling along a distant freeway. A few minutes later you look again and see two cars 10 times farther apart. Since you weren't watching all the time, you can't be sure that you are seeing the same two cars; one might have stopped and switched off its lights, and another might have started up at a more distant point along the road. You would not know how fast the cars had really traveled.

This is similar to the problem with the radio data, since the observations were spread six months apart and no one knows what happened between observations. Did the sources actually move apart, or did one fade and another start to shine at a different point in the quasar?

Using three radio telescopes working in combination from sites in California, West Virginia and Texas, quasar 3C273 has been much more carefully watched over the last two years. The new observations have cleared up some problems but also have raised new ones. First, the core in 3C273 contains not two but three small sources in a line. This, however, does not help explain the faster-than-light problem since now the triple source appears to be moving apart. The simplest interpretation of that motion indicates that the outer elements are each traveling at five times the speed of light away from the quasar's center.

The separation between parts of the triple source is a few thousandths of a second of arc, and the rate at which they move apart as seen against the background of the sky is only a few tenths of a thousandth of a second of arc per year! At the distance of 3C273, these individual components are only a few light-years apart. But in another year's time they should be about 10 light-years apart if the observed effect does indeed indicate faster-than-light travel. No one yet accepts that explanation, and now several other possible reasons for the phenomenon which do not require faster-than-light travel have been proposed.

The first alternative explanation questions the distance to the quasar. If 3C273 is, say, 10 times closer than thought, the speeds involved are all 10 times less. This means that we would not have to worry about faster-than-light travel but instead have a problem of explaining the redshift discrepancy. Up to now we have believed that the redshift effect was a manifestation of the expanding universe. Objects farther away from us appear to move away faster; hence, their speed (or redshift)



If quasar 3C273 is much closer to Earth than now believed, the radio "blobs" are not traveling apart at faster-than-light speeds. For example, if 3C273 is 10 times closer, its two components would only move at 1/10 the speed and cover 1/10 the distance. Although this explanation solves the faster-than-light *dilemma, it means* astronomers cannot rely on the redshift effect for measuring the size of the universe, and that the universe may be smaller than currently believed.

Artwork by Victor Costanzo

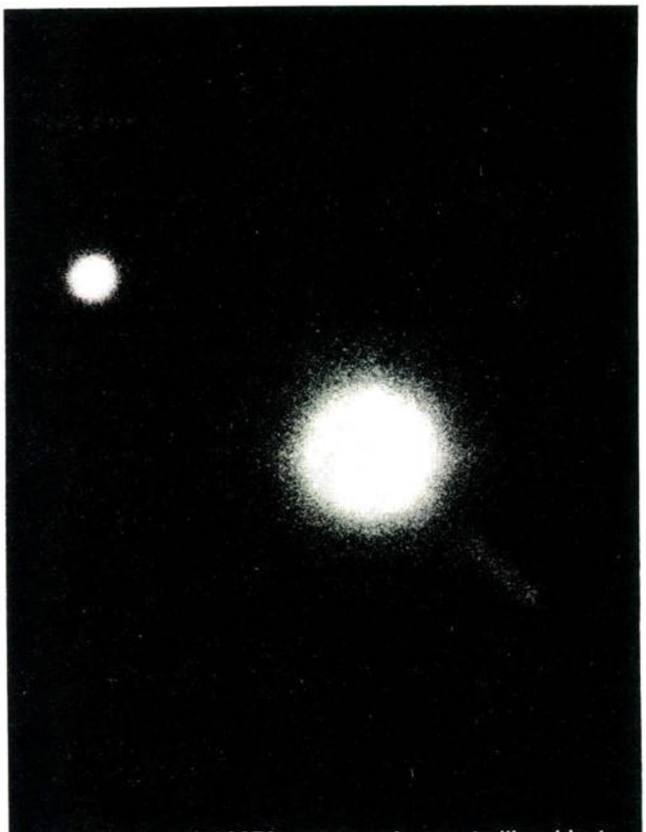
gives a distance estimate. If quasar 3C273 is much closer than believed, we have to ignore the distance estimate based on the redshift. In that case, what is producing the redshift? Does it call for a reworking of our concepts of the expanding universe? Because this explanation for the faster-than-light effect raises a lot more questions than it answers, astronomers are hesitating to accept it.

An illusion of faster-than-light travel could be produced if the component parts of the double (or triple) source are flying away from the quasar's center along a line aimed nearly toward us. The expanding parts might be traveling very nearly at the speed of light, but produce the illusion of faster-than-light travel as a consequence of Einstein's physics.

It works this way: Imagine a part of the source approaching us at almost the speed of light. If it sends out a pulse of light followed by another pulse a year later, we would see the pulses arriving at Earth at nearly the same time. This is because the object is traveling at near-light speeds in the *same direction* as its Earthward bound light pulses. Since the blob is not heading precisely toward us, its incoming pulses would still appear to be moving outward from the quasar's center — but they would arrive here a short time apart, implying that the object must have traveled very fast between two locations. In fact, by Einstein's equations of relativity, we would conclude that the blob shot between those two points at several times the speed of light unless we assume that the object was moving nearly along our line of sight. In that case, a speed of 99.5 percent the velocity of light would explain the observations for 3C273.

Nevertheless, this solution leads to other problems concerning the radio components. Since energy from the receding blob of matter is expanded or *redshifted* and the approaching blob's energy is compressed or *blueshifted,* radiation coming from the two locations should have very different intensities or frequencies. But observations show that intensities are not very different from one another in any of the cases of the faster-than-light radio sources so far observed. This suggests that the blobs hurtling apart must contain different amounts of energy that are being shifted by high velocity such that their frequencies appear nearly equal. Such an unusual situation is very difficult — but not impossible — to accept.

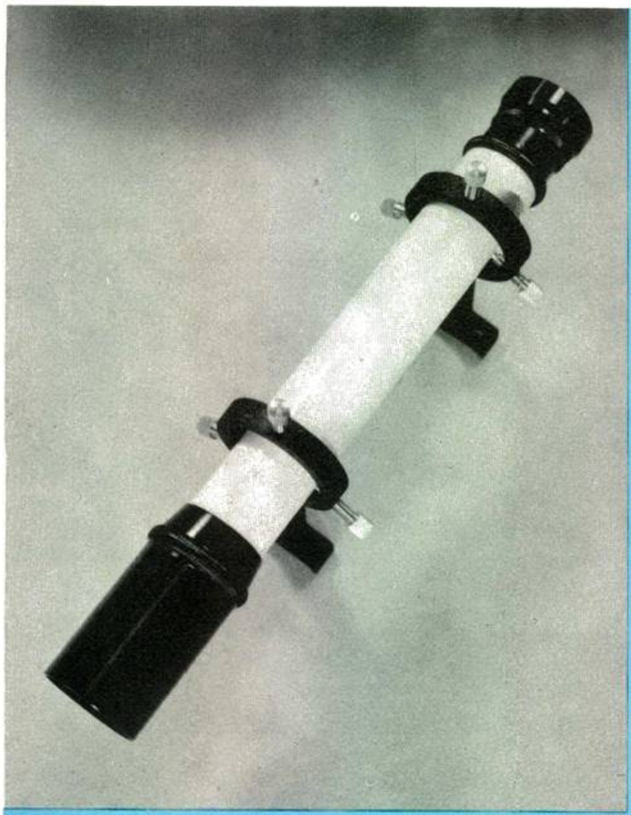
We have three possibilities for explaining apparent faster-than-light motions in several quasars. First, perhaps there really are elements of matter moving apart at speeds greater than light — meaning that Einstein's theory of relativity is wrong and a lot of our basic physics is in trouble. Second, quasars might be closer than indicated by their redshifts — thus requiring a new explanation for the redshift effect. This is also not possible in the context of our present knowledge of physics since we would have to question *all* redshift measurements and hence the expanding universe model. Third, it is possible to produce an illusion of faster-than-light expansion if two components are moving away and toward us across our line of view. But it is hard explaining why the components have nearly equal intensities. More importantly, why are large clouds of matter in quasars accelerated to within a half percent of the speed of light? The amount of energy required to do that task is extraordinarily large.

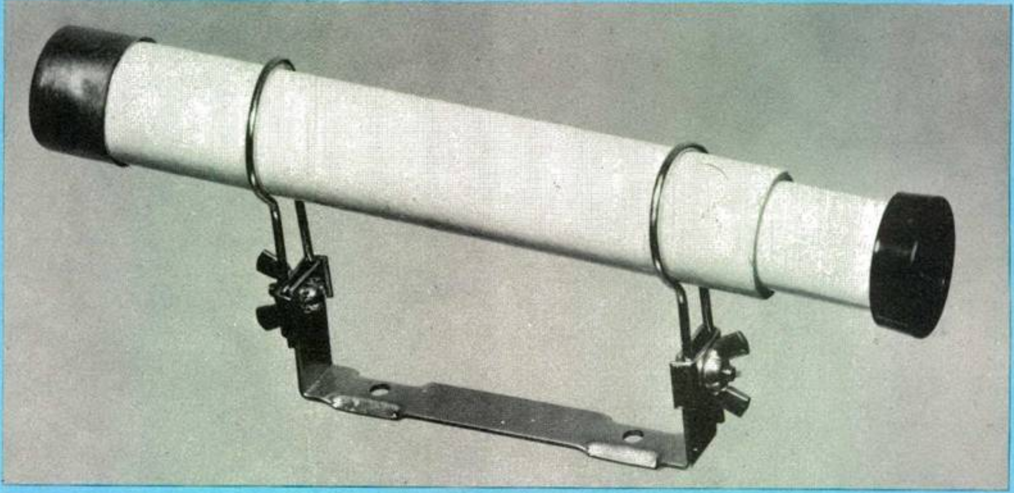


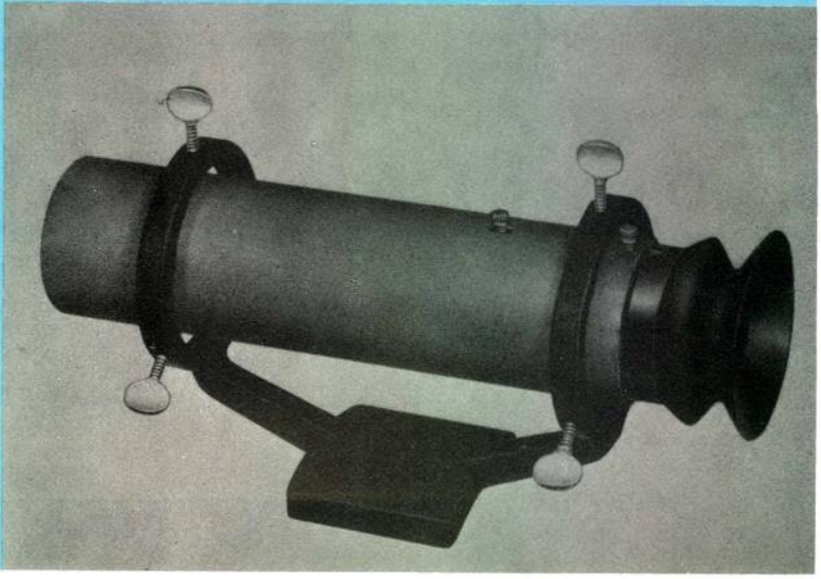
Optically, quasar 3C273 appears only as a starlike object. Its only identifying feature is an incredible 300,000 light-year-long jet of matter apparently streaming away from the quasar's visible center.

Hale Observatories Photograph

None of these answers is fully satisfactory at this time. While no one is seriously worrying about Einstein's laws of relativity being overthrown in the near future, we *are* stuck with explaining how bits and pieces of quasars' central parts are being thrown around at such tremendous speeds. Our knowledge of this problem will continue improving as more observations of quasars are made by the ever vigilant "Quasar Patrol" (the group of radio astronomers that regularly measure the sizes and intensities of quasars). More likely, the true explanation of this phenomenon may have to wait until we at last discover what quasars themselves are. Whatever the final solution, astronomers had better brace themselves for the possibility that the quasar puzzle might shatter a few trusted beliefs.

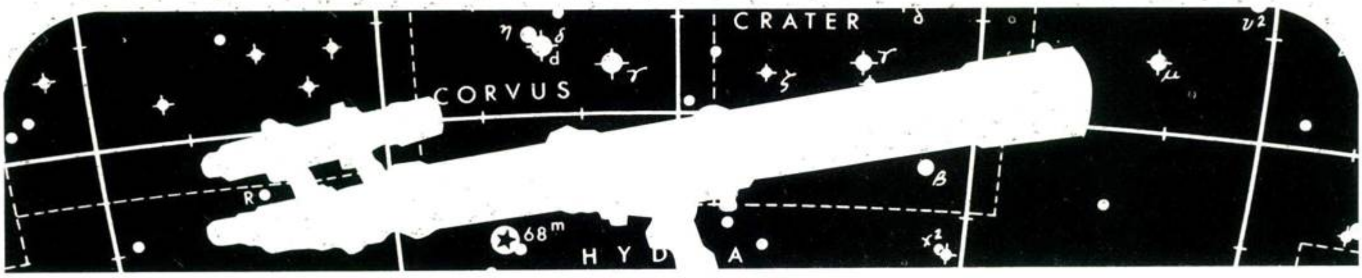






Telescope finders come in a broad range of sizes and styles. Selecting the appropriate type for your telescope requires carefully matching a finder's magnification against the field of view provided. Typically, magnifications range from 3 to 10 power, and finder fields of view vary from three to eight degrees across. Both refractor and reflector type finders are available. In fact, some war surplus items such as elbow telescopes and monoculars make excellent instruments.

Edmund Scientific Co. Photographs



The Finderscope

by

James Mullaney

One of the most neglected telescopic accessories today is the finderscope. Both telescope manufacturers and telescope users are frequently guilty of underestimating the finder's usefulness. A good finder enables the observer to quickly and accurately point his telescope at a desired celestial object. Telescopic fields of view are rarely more than a degree wide even at low power, making it difficult to locate even the moon by simply aiming the tube itself.

On the other hand, a good finder typically boasts a field of at least four degrees — eight full moon diameters, or 16 times the sky area visible in most telescopes. Equipped with crosshairs and properly aligned with the main instrument, a good finder makes sighting even faint objects a cinch, and can occasionally provide spectacular views of the heavens. The following is a "no nonsense" survey of the various practical aspects of this badly underrated tool.

Sizes and Types

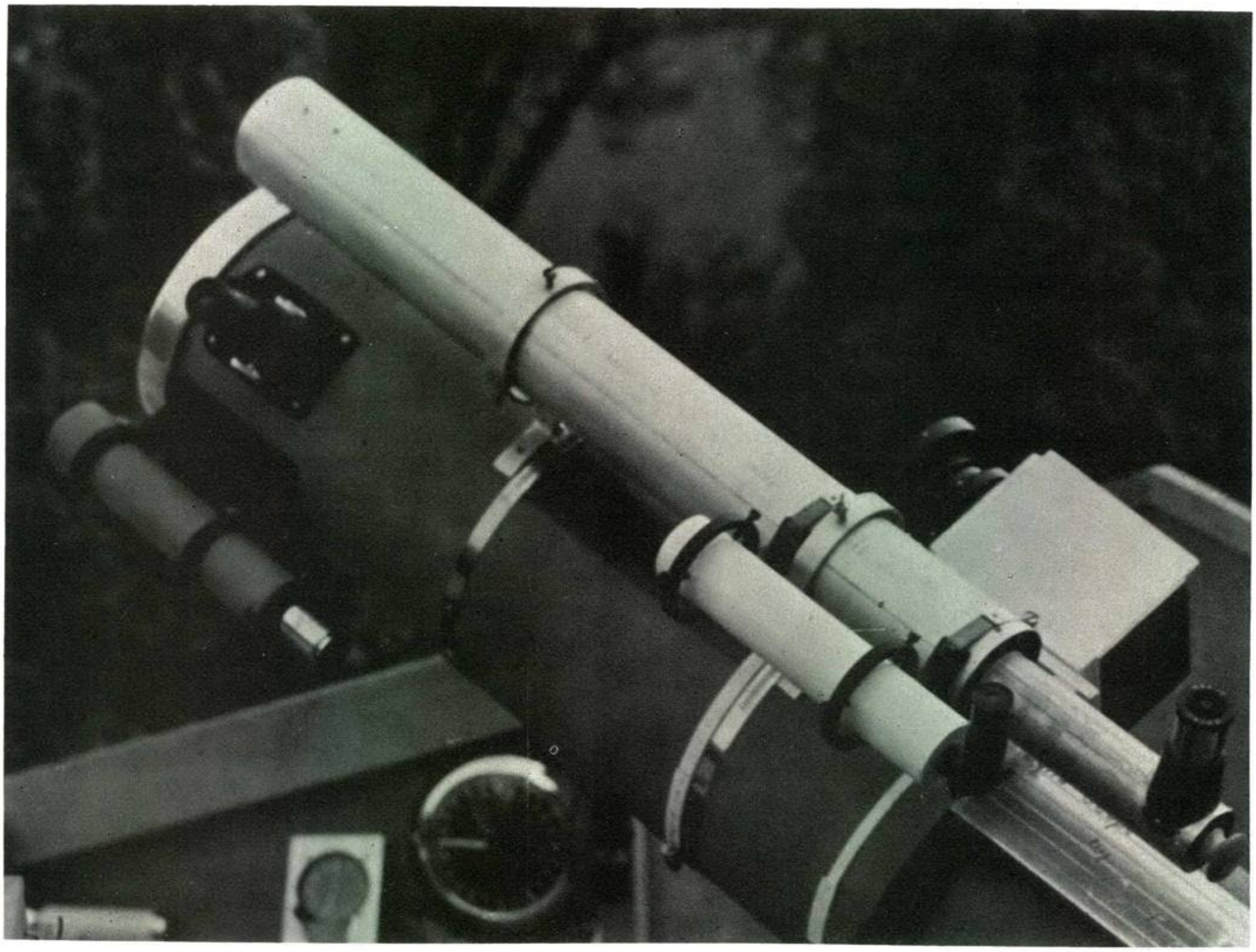
While simple V-grooves like those used for gunsights or even a hollow tube beanshooter with thread crosshairs at each end can, and indeed have served as locating devices for telescopes, a true finder is a real optical instrument in its own right.

Without question, the single biggest mistake which amateurs (and many commercial manufacturers, too) make regarding the selection of a finder for their telescopes is in choosing one too small for the job. Although a six or eight power spotter of 25 or 30mm aperture may be adequate for the modest light grasp of a 2.4 (60mm) or 3 inch refractor, it is grossly inadequate for locating the host of fainter objects visible in a six or eight inch telescope. A good rule of thumb here is that *a finder's aperture should be at least 1/4 the size of the telescope it is riding*. Thus an eight inch instrument should have at least a two inch finder. Professional astronomers and instrument makers long ago learned the importance of their finders having sufficient light gathering ability, as a visit to any major observatory will show.

Probably the ultimate in spotting scopes are *richest field telescopes* (see Equipment Atlas, June 1975), which are either short-focus reflectors (f/4 to f/5) or refractors (f/5 to f/8). Apertures of three to six inches are common for such instruments, supplying plenty of light for faint objects. The refractor is somewhat preferable over the reflector due to better image quality (lack of coma) at the edge of the field, but both types make excellent finders.

Note that in using a reflector (or refractor equipped with a star diagonal) as a finder, you must sight along the side of the tube for initial pointing since the eyepiece is placed at right angles to the line of sight. The finder itself should be placed conveniently near the telescope eyepiece assembly — its exact position being a matter of such factors as personal comfort and which eye you normally use.

The richest field telescopes (RFTs) produced by such firms as Edmund Scientific, A. Jaegers, Cave, Tuthill and University Optics — among others — make excellent finding telescopes. Some of these manufacturers also offer individual components such as short-focus objectives and mirrors that can be assembled, as well as more conventional



Photograph by Robert C. Dickinson

This eight inch Criterion Newtonian telescope is equipped with a 3.5 inch guiding refractor and a 50mm seven power finder.

The 3.5 inch refractor also has a finder. A finder's aperture should be at least 1/4 the size of the telescope it is mounted to.

completed finders in the 25 to 60mm aperture range.

Some war surplus items — such as the once popular M17 and other elbow telescopes — can often serve as good finders. One of the best practical answers is a 50mm monocular (half of a binocular). These excellent instruments combine good light grasp and sharp images with economy.

Magnification and Field of View

In general, the higher the magnification used, the smaller the sky area visible in a given instrument. In addition to sufficient light grasp, a good finder must balance magnification against adequate field of view — a delicate balance indeed!

Most small commercial finders have powers from 6 to 10 and give fields from three to eight degrees across. Too wide a field and too little magnification will not reveal enough detail for seeking faint extended objects such as distant clusters and galaxies. A field diameter around three or four degrees is just about ideal. As for optimum power, another rule of thumb is to *use about five power per inch of finder aperture* — 10 power on a 50mm, 15 power on a three inch and so on. The resulting combination of light gathering, magnifying and resolving power is quite striking and makes for a most effective spotting scope.

Crosshairs and Illumination

To achieve its function of bringing distant celestial wonders into the view of the main telescope, the finder must have some means of clearly and accurately indicating the exact center point of its field (or the location of its optical axis). This is often accomplished with the use of a *reticle* — a glass disc with an engraved, etched or photographed pattern placed in the focal plane of the eyepiece. This pattern may be one of a number of designs including a central spot, ring, pointer or crosshairs, which indicates the precise center of the field. Most observers prefer the basic crosshair type.

Some amateurs make their own crosshairs by stretching thin wires across a ring which is then placed in the focal plane. (A few diehards still employ the old practice of using spider webs! These, however, are somewhat on the thin side for finder hairs.) The wire used should be thick enough to be readily seen against the sky, but not so thick as to block an appreciable amount of the field. A good compromise seems to be one or two mil thick tungsten wire which is available commercially.

Wide-angle eyepieces such as Kellners or Erfles with crosshair reticles already built into them are available from a number of companies at reasonable prices. A 50mm coated achromatic binocular objective combined with such an eyepiece makes a superb finder for most amateur size scopes.

Illuminating the crosshairs to make them visible against the night sky is a handy addition to your equipment. One method known as *dark field illumination* keeps the field dark, but faintly lights the crosshairs — usually with a battery operated wheat-grain bulb throwing light through a small hole in the side of the eyepiece assembly.

An opposite technique known as *bright field illumination* keeps the crosshairs dark and faintly illuminates the field — usually with the wheat-grain bulb shining directly on the eyepiece field lens. In this case, the hairs or wires are simply silhouetted against the bright sky background that results. Unfortunately, this method reduces the magnitude limit of the finder and affects the eye's dark adaptation.

The method most observers use is related to the second technique by making use of the sad fact that the sky is seldom really dark anymore — especially in and near large cities. No source of actual illumination is needed, for the crosshairs are silhouetted against the night sky's bright background. Unless the night is unusually dark or the lines or wires used are too thin, this serves well under actual observing conditions with average levels of light pollution in the sky.

Whenever artificial illumination is used, red light should be used to preserve the eye's dark adaptation. Also, a *variable intensity control* (potentiometer or crossed polaroids, for example) should be incorporated into the design since the darkness of the sky can vary greatly from night to night.

Mounting and Alignment

A very real headache to many observers is the relatively simple task of attaching the finder to the telescope itself, so that both their optical axes are exactly parallel to each other — that is, looking at precisely the same point in the sky.

Many different methods have been devised through the years for accomplishing this objective, and ingenuity is just as important here as in other areas of astronomical instrumentation. However, the time-proven method is the use of *ring mounts* consisting of one or two open rings large enough to loosely hold the finder within them, and having bracket bases for mounting directly onto the main telescope tube. Each ring has three threaded thumbnuts (120 degrees apart), screwed through the rings and touching the finder tube. These hold the finder securely in place and also permit position adjustments.

The single ring devices supplied commercially consist of a short tapered sleeve or collar which snugly fits the finder tube at one end and holds it with three threaded adjusting screws at the other. This simple, self-contained unit permits finder alignment using only one set of screws — whereas the double ring system has two sets or a total of six screws to be manipulated.

Although actual alignment (or *collimation*, as it is called) can be undertaken on a distant terrestrial object or the moon at night, the best collimation source is a bright star. The object is first centered in the field of a low power eyepiece in the main instrument, and the finder is adjusted by trial and error with the thumbnuts until the star is at the intersection of the crosshairs. This requires some patience, and frequent checking between finder and telescope is necessary to check for telescope motion during the screw adjustment.

Once centered with low power, the process is repeated with a high magnification. After satisfactory alignment has been achieved, each screw should be tightened securely and the final collimation checked again to be sure nothing has moved. The system should be tried on bright stars in different parts of the sky to be sure there is no play or bending between the two instruments as they change position. It is always a good practice to check alignment before each night's observing. The cool-down/dark adaptation period that should precede every session is ideal for making any necessary adjustments.

Some observers purposely offset the finder just slightly so that the target object falls near but not directly behind the intersection of the wires. With really thick wires, objects disappear behind them — sometimes causing some difficulty in exact centering. It then becomes important to keep tabs on which quadrant is being used as the telescope moves to different parts of the sky.

In summary, a well adjusted finding telescope of sufficient aperture, field of view and magnification is a vital asset to the active observer and a very real pleasure to use. Not only does it make locating celestial objects quick and easy, but it can provide breathtaking views of the night sky known only to binocular and RFT users. Indeed, the humble finder on your telescope is as an open window on the heavens — an instrument of which the giants of Copernican and Galilean days might well have been proud.

James Mullaney has used telescopes up to 30 inches aperture to examine thousands of double stars, clusters and galaxies during the past two decades. As a contributing editor to ASTRONOMY, he prepares the Eyepiece Impressions section of our mohthly Star Dome department.

SKY ALMANAC

PLANETS DESERT SUMMER SKY

The Perseid meteor shower which peaks at midmonth will highlight August skies. The bright planets will not be in favorable positions to offer much pleasure this month, though there is promise of more favorable observing in the future. As a special feature, several pictures and accounts of the May 24-25 lunar eclipse from ASTRONOMY readers round out August's Sky Almanac.

Mercury

The innermost planet sets almost with the sun during the early part of August, and will be too close to the sun for easy observation during most of the month.

Venus

Venus is no longer the glamorous beauty she was earlier this summer. During the first week of the month, Venus may still be seen very low in the west just after sunset, shining at about magnitude -4.0. Our sister planet's cloud-shrouded disk is 18 percent illuminated on the 1st, but by midmonth it slims to a six percent crescent at which time the nearby sun makes the planet observable until September.

The first part of August finds Venus 35 million miles away, with an apparent diameter of 45 seconds of arc. By month's end the planet moves within 27 million miles of Earth.

Mars

Mars, the red god of war, rises late throughout August. Mars' distance from Earth ranges from 113 million miles at the beginning of the month to 97 million miles by the end — thus remaining relatively distant for observing surface features.

Currently in the zodiacal constellation Taurus the bull, Mars begins rising slightly earlier — about midnight — at the end of the month, and on Aug. 31, the war god battles the brightness of Taurus' red eye — Aldebaran. Situated four degrees north of the star, Mars' magnitude of +0.2 competes poorly with Aldebaran's -0.7. Still, the two brilliant red objects so close in the sky make a unique pair.

Jupiter

Jupiter is in the morning sky for all of August,

Satellite Shadows on Jupiter

Date	Satellite	Transit Begins (EST)	Transit Ends (EST)
Aug. 1	2	2:40 a.m.	5:24 a.m.
2-3	1	10:51 p.m.	1:01 a.m.
3	2	2:28 a.m.	5:11 a.m.
5	3	4:53 a.m.	7:53 a.m.
10	1	12:44 a.m.	2:54 a.m.
	2	5:05 a.m.	7:48 a.m.
17	1	2:38 a.m.	4:48 a.m.
18	1	9:06 p.m.	11:17 p.m.
20	2	9:00 p.m.	11:42 p.m.
24	1	4:32 a.m.	6:42 a.m.
25-26	1	11:00 p.m.	1:10 a.m.
27-28	2	11:37 p.m.	2:10 a.m.
31	1	6:25 a.m.	8:36 a.m.

1 = Io **3 = Ganymede**
2 = Europa **4 = Callisto**

The lunar eclipse as seen on Kodak Ektachrome Infrared film records not only a blue-green moon, but higher contrast on the lunar surface. Kansas City, Mo. was the scene of this 30 second exposure made with a Ricoh Singlex camera using a K2 filter at prime focus on a home built 10 inch, f/5.6 telescope.

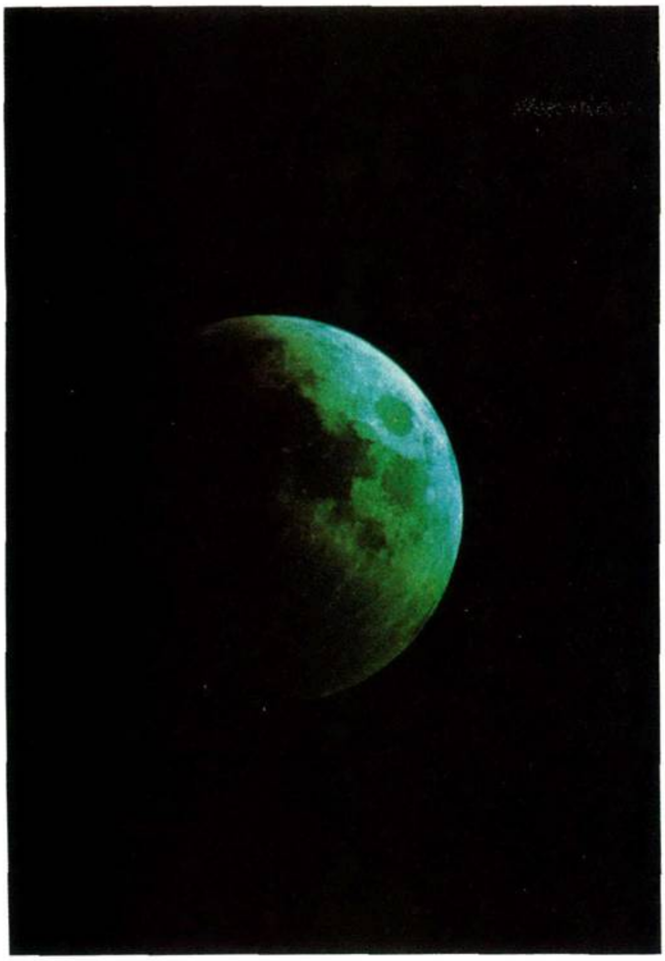
Photograph by David Hudgins

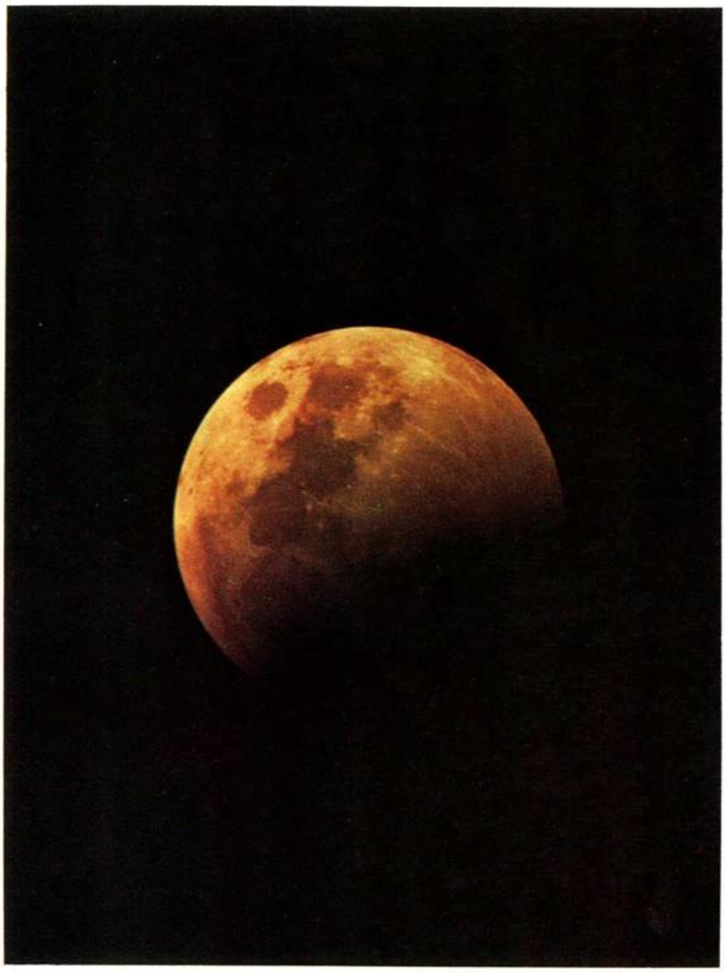
The total eclipse and the surrounding bright stars in Scorpius embellish California skies. A Minolta SRT-101 equipped with a 135mm lens at f/2.8, combined with a two power telextender recorded the event on GAF 500. The camera was mounted piggyback on a Celestron 8 (f/10) telescope.

Photograph by George Hodgkinson

The deep red color of the May 24-25 total lunar eclipse is shown in this photo from Norman, Okla. The six second exposure was made on High Speed Ektachrome at ASA 400, taken at prime focus on a 12-1/2 inch, f/6 telescope.

Photograph by Mike Pierce




A

B

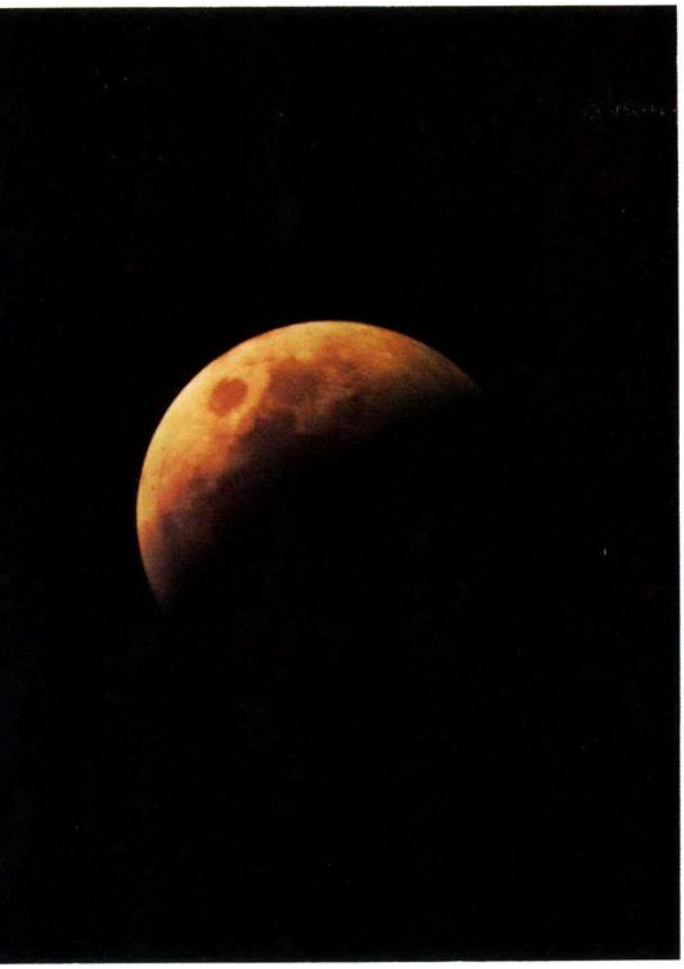
SATELLITES OF JUPITER AUGUST

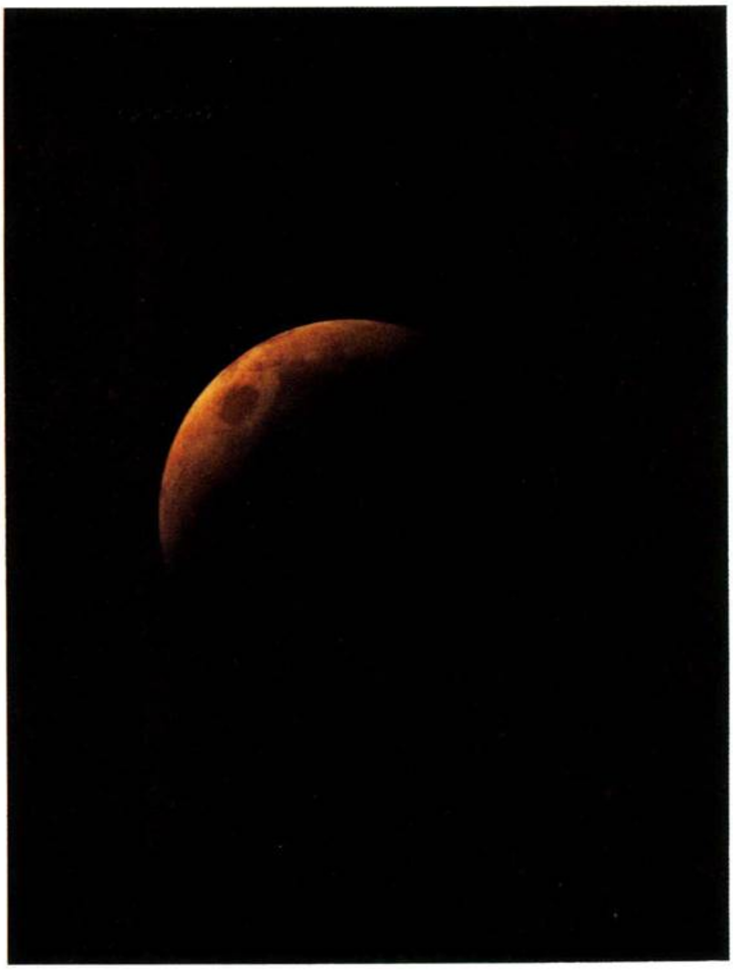
1	43201	• • •●•	16	41302	• ••●•
2	41032	• •●• •	17	4023	• ●• •
3	4023	• ●• •	18	42013	• • ●• •
4	42013	• • ● • •	19	41203	• ••● •
5	41023	• •●••	20	43012	• •●• •
6	30412	• ●•••	21	4310	•• •●
7	31204	• ••● •	22	32401	• • •● •
8	32014	• •●• •	23	13042	••● ••
9	1024	•● • •	24	01234	●••• •
10	0234	●• • •	25	2034	• ● • •
11	2034	• ● • •	26	12034	••● • •
12	1034	• ●• •	27	30124	•●•• •
13	30124	• ● • • •	28	3104	• • ● •
14	3120	• ••●	29	32014	• • ●• •
15	32401	• ••●•	30	13024	• •●• •
			31	0132	●•••

and will not be visible in the early evening until November. The giant planet, located in Pisces, rises around 11:00 p.m. early in the month and appears progressively earlier, until by the end of August Jupiter's brilliant face (magnitude -2.2) glimmers in the east barely more than one hour after sunset. Since it rises so late, the planet is not well placed for observation until well after midnight. However, the four major moons are easily seen telescopically as soon as Jupiter clears the horizon haze.

Earth is now getting closer to Jupiter. The sun's largest planet opens August at a distant 429 million miles from Earth, and by month's end decreases that distance by 37 million miles. Jupiter's equatorial and polar diameters increase accordingly

The four major satellites of Jupiter orbit the giant planet in periods ranging from just under 2 days to 17 days. They can be seen to change position from night to night. Sometimes their motions become evident after only a few minutes' observation. Only a small telescope is required to detect all four of the satellites and several can frequently be seen in rigidly held binoculars. This table shows the approximate positions of the moons at about 3 a.m. (EDT) on the evenings indicated. First column on the left shows the date. Second column of numbers identifies the moons and their positions relative to Jupiter's disk. (1=Io; 2=Europa; 3=Ganymede; 4=Callisto, and 0= Jupiter's disk.) The third column approximates a telescopic view of the satellites' positions. The orientation of the satellites is shown inverted as seen in a standard astronomical telescope.





D

Photographs by Allen A. Brunk

This photo sequence reveals the progression of the May 24-25 lunar eclipse as seen from Sleepy Hollow Park in Chesapeake, Va. Exposures were made with a Pentax Spotmatic F mounted on a Criterion six inch Newtonian telescope. High Speed Ektachrome was used, with the ASA pushed to 400. Exposure times are as follows: A) 1/250 second; B) 1/125 second; C) 1/60 second; D) 1/30 second. Eight minutes separates the first two exposures, and approximately 20 minutes the remaining shots.

from 43 to 46 seconds of arc (equatorial), and 41 to 43 seconds of arc (polar).

Saturn

Observers of the ringed planet will have to be up before the sun during August. Now a morning object (magnitude +0.4), Saturn rises at 4:00 a.m. on the 1st and about 2:00 a.m. by month's end. The planet moves from the constellation Gemini into Cancer, but observing Saturn really will not be worthwhile until early in 1976.

Earth is now approaching Saturn; our distance in early August is 933 million miles. By the end of the month we will be 20 million miles closer.

The Perseids

The Perseid meteor shower peaks on Aug. 12 this year, and fortunately this normally spectacular display will not be hampered by the moon approaching its first quarter phase. Since the moon sets before midnight, the best part of the shower will be unhampered except by the traditional hazard — clouds.

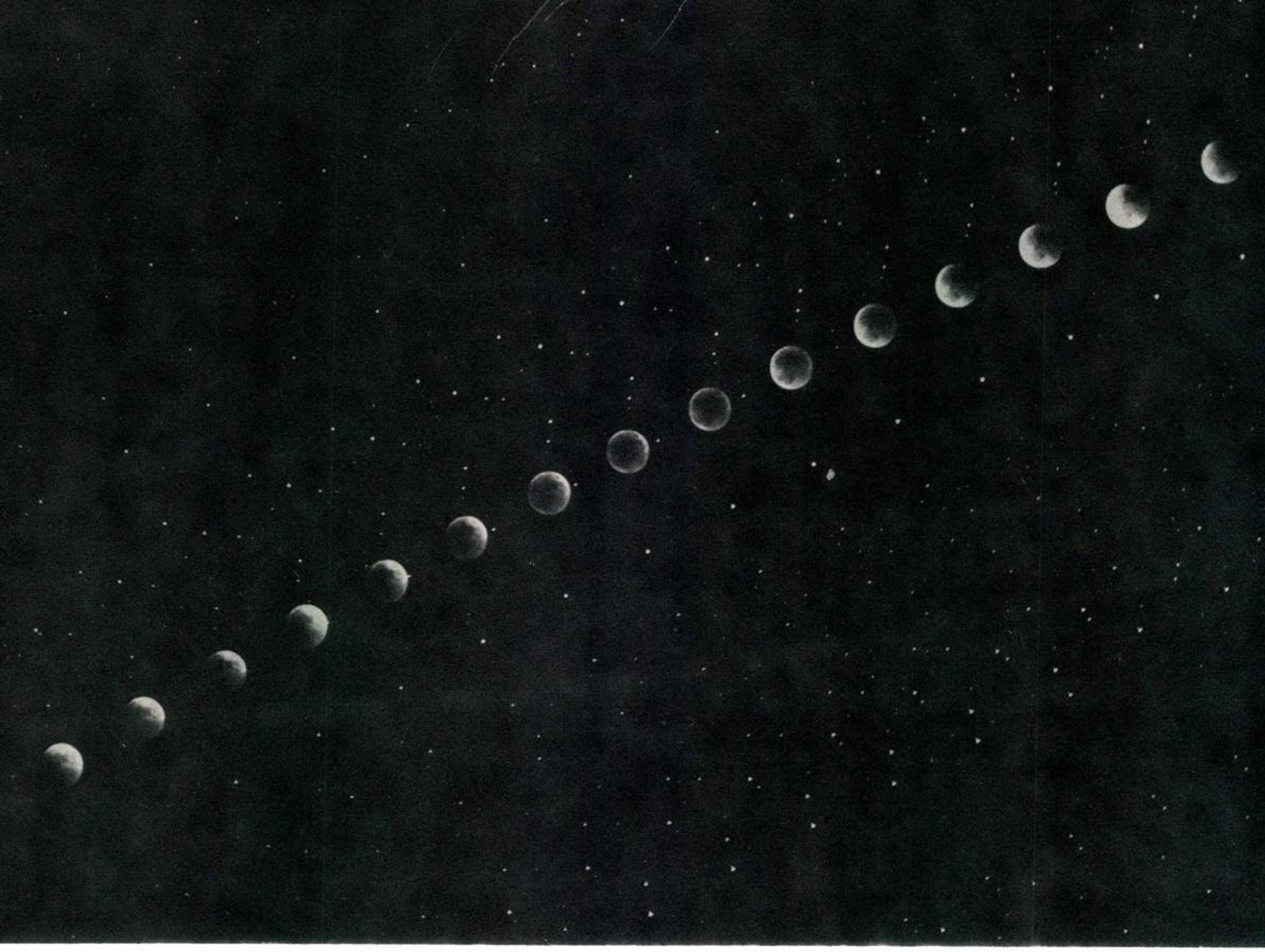
The shower appears to radiate from the north edge of Perseus, and meteor enthusiasts will probably see the best display on the nights of Aug. 11 and 12. Photographers are encouraged to try to "catch a falling star" and send us the results. The Perseids are featured in this month's Gazer's Gazette.

Lunar Eclipse Observations

In the May 1975 issue, we titled our article on the moon's May 24 eclipse, "Lunar Eclipse of the Decade". It was.

Dark lunar eclipses are always more spectacular than lighter ones, and fortunately this was among the darkest of the century. Most of our readers who reported to us thought the eclipse was either L = 2 (41%) or L=1 (35%) according to Danjon's scale described in the May article. An eclipse rated L = 1 is a dark gray or brownish eclipse; lunar details are distinguishable only with difficulty. An L = 2 event is described by Danjon as a deep red or rust colored eclipse with the central part of the shadow very dark and the outer edge of the umbra relatively bright. Probably because the eclipse contained qualities from both classifications, the decision was difficult — thus accounting for the nearly even split.

Most of the midwest was under clouds, but



Photograph by Edward E. Robinson

This lunar eclipse sequence from Los Alamos, N.M. was captured on Tri-X film in a Mamiyaflex 2-1/4 x 2-1/4 camera with a 135mm f/4.5 lens. The exposure was made at five minute intervals, and the film developed for 10 minutes in D-76.

observers in the east and west were generally under clear skies. Some of our readers report they thought the moon at midtotality was as dim as Antares. Others said it was brighter, but not by much. That means the moon's brightness plunged at least by a factor of 200,000 and probably more.

Those who ended up cursing the clouds instead of enjoying the eclipse can perhaps get some flavor of the event by the following comments from more fortunate readers.

"The moon was bright enough... to easily see all of the seas and several prominent craters, especially on the west side of the moon."
Brent A. Archinal and Robert S. Bush, Columbus, Ohio

"...the moon looked like warm coal glowing in the dark sky."
Donald H. Talbert, Greensboro, N.C.

"...the umbra was evident as a narrow shadow band.... resembling the roll-cloud of an advancing squall line. Coloration was a very deep, dark reddish-gray."
Richard A. Sweetsir, Jacksonville, Fla.

"...the moon's... center appeared brown-red.... The surrounding ring was orange-yellow, making the moon resemble a donut...."
Craig Martinsen, Canoga Park, Calif.

"...the fading of the moon was significant and my notes were becoming hard to read by the existing light. All of the dogs in the neighborhood seemed to be yapping their heads off about this time. Lunacy? ...the orange color on the eclipsed moon was... easily seen with the unaided eye. Seven minutes after the end of totality the view through binoculars was strikingly beautiful. The moon was a translucent sphere illuminated from one side, with gradations from brilliant milky white to gray, and then to orange at the southwest limb. It was quite dramatic."
Derek Wallentine, Albuquerque, N.M.

"...stars of sixth magnitude could be discerned — the sky appeared as dark as a moonless night."
Dan and Robert Duriscoe, Van Nuys, Calif.

"...the moon reminded me of a greatly enlarged planetary nebula...."
Joe Sheppard, Atlanta, Ga.

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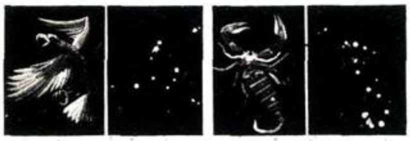

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FOR SALE — 4-1/4" f/15 refractor with equatorial mount, clock drive, setting circles, star diagonal, dew cap, counterweights for photography, 22mm (1-1/4") eyepiece. Price: $300.00. Send SASE to James W. Chase, 3 Morris Rd., R.D. #1, Stanhope, NJ 07874. Or call (201) 398-3618.

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FOR SALE — Criterion Dynamax 8 with all accessories. Less than 1 year old; need money for school. Serious inquiries only. Contact Edward L. Vaughan, 2501 S. Crumpton Circle, Richmond, VA 23224. Phone (804) 276-8783 after 6 p.m.

FOR SALE — GAF Lentar telephoto lens (200mm f/3.5) in Pentax/Praktica screw mount. Includes case, screw-in lens shade, screw-in 67mm skylight UV filter. Price: $60.00 postpaid. Write Walter Gottlieb, 2 Cypress Rd., Eastchester, NY 10709.

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FOR SALE — 3-1/2" Questar with Cer-Vit mirror; broad band low reflection coating. Mounts both field model and standard with power guide. Includes 2 eyepieces; most accessories. Mint condition; 1/2 current list price. Write Lee Prusia, Box 1622, Alameda, CA 94501.

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WANTED — Authentic tektites and meteorites. Send size, description (photo if possible) and cost to Joseph M. Kaleel, 105 Cornell Ave., Elyria, OH 44035.

WANTED — Good, inexpensive, small (about 3") reflector; preferably with several eyepieces. Send information to Craig Callewart, 10430 Strait Ln., Dallas, TX 75229.

WANTED — Space models, new or already built; will pay top price. Also books, publications, films on astronomy and UFOs. Write Edward Szymoniak, 9247 Highland Pl., Highland, IN 46322.

WANTED — Persons interested in science fiction to join correspondence club; be eligible to write for our club journal. Write David Kleist, 204 S. Main St., Telford, PA 18969.

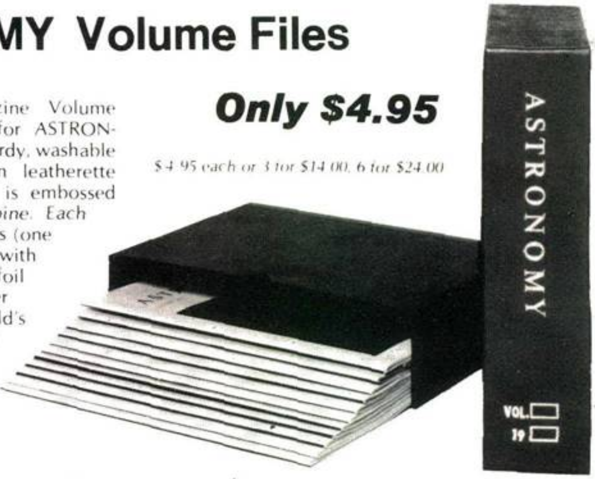
WANTED — Equatorial mount with clock drive for 6" reflector (with or without pedestal). Write Michael Gurnis, 50 Reservoir Rd., Cohasset, MA 02025.

WANTED — Correspondence from owners of Criterion RV-6 Dynascope. Write Robert Hall, 72 Pine St., North Massapequa, NY 11758.

WANTED — Correspondence with other curious minds and active science fiction fans. Anyone, any age. Write Paula Gold, 2720 Coy St., Cincinnati, OH 45219.

WANTED — October and December 1973 issues of ASTRONOMY. Will pay $5.00 each. Write Emil J. Kaczor, Physics Department Library, Wayne State University, Detroit, MI 48202.

WANTED — October, November, December 1973 issues of ASTRONOMY. Will pay up to $5.00 each. Write Andrew Lowe, R.R. #2, Ardrossan, Alberta, Canada T0B 0E0.



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WANTED — Back issues of ASTRONOMY: September through December 1973; January and February 1974. Will pay $3.00 per copy if in good condition. Write Glenn Meadows, 800 S. Washington St., Alexandria, VA 22314.

WANTED — Pen pal in 12-14 age group to exchange astronomy information and observations. Write Ray Swartz Jr., 3024 Woodlawn, Walled Lake, MI 48088.

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WANTED — One copy each of October and December 1973 issues of ASTRONOMY for college science library. Many students will be appreciative. Send to Prof. John Charlesworth, Napa College, 2277 Napa-Vallejo Highway, Napa, CA 94558.

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WANTED — Camera to telescope adapter for astrophotography. For Bell & Howell auto 35 reflex to 6" reflector 1-1/4" mount. Write Allan S. Cutler, 7712 W. Armitage Ave., Elmwood Park, IL 60635.

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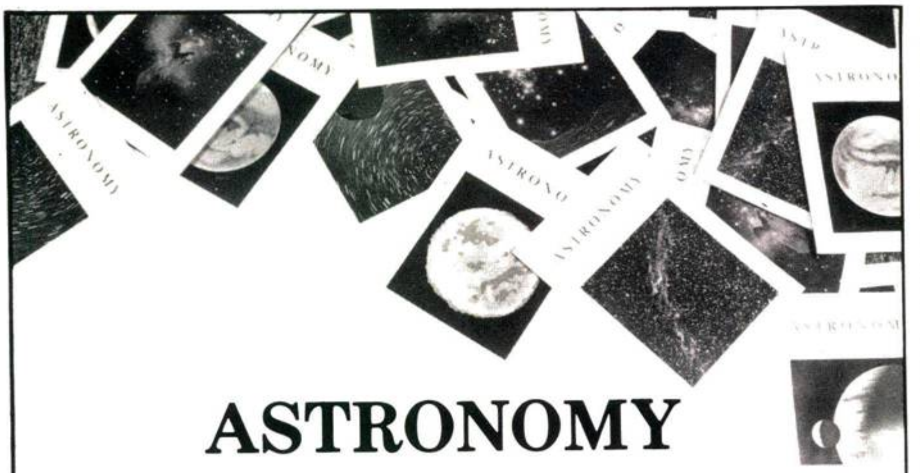
We have received complaints with respect to **Essential Optics, Box 718, Big Bear City, California 92314.** Specifically, subscribers have complained that their telescope orders have not been acknowledged when received and that there have been unreasonable delays in filling orders; one subscriber was charged more for shipping than the advertised price and another subscriber reports he was refused return of his deposit and was treated discourteously when he reached the company by telephone. Complaints directed to the company were unanswered. We wrote and telephoned **Essential Optics** on behalf of dissatisfied subscribers and they were uncooperative in resolving these complaints. For that reason we have withdrawn this company's advertising from ASTRONOMY magazine. If any readers have had difficulty in their dealings with this company, we will be happy to lend our assistance in resolving your dissatisfactions. We regret the inconvenience that may have been caused to our subscribers by **Essential Optics**' advertisements which we carried in our magazine. *Stephen A. Walther, Publisher.*



ASTRONOMY

Guide to Back Issues

Reader interest in back issues of ASTRONOMY magazine is higher than ever. As a result, our stock of back issues is swiftly dwindling. The following back issues are depleted: September, October, November, December 1973; January, February, May, August, October, December 1974; March and April 1975.

Below is a guide to ASTRONOMY back issues that are still available. For your convenience it is updated monthly, and completely revised about every six months. While they last, back issues are available for the cover price of $1.50 each (price includes postage).

When ordering, please clearly state quantity, volume, number, month and year for each issue (first issue was August 1973), and include payment with your request. If issues ordered are no longer available, unless you instruct us to forward a refund or substitute issues, we will automatically extend your subscription appropriately.

Vol. 1, No. 1 - August 1973	**Available**	**Vol. 3, No. 8 - August 1975**	**Available**
Vol. 2, No. 3 - March 1974	**Available**	**Vol. 3, No. 9 - September 1975**	***NYP**
Vol. 2, No. 4 - April 1974	**Short Supply**	**Vol. 3, No. 10 - October 1975**	***NYP**
Vol. 2, No. 6 - June 1974	**Short Supply**	**Vol. 3, No. 11 - November 1975**	***NYP**
Vol. 2, No. 7 - July 1974	**Available**	**Vol. 3, No. 12 - December 1975**	***NYP**
Vol. 2, No. 9 - September 1974	**Available**	**Vol. 4, No. 1 - January 1976**	***NYP**
Vol. 2, No. 10 - October 1974	**Available**	**Vol. 4, No. 2 - February 1976**	***NYP**
Vol. 2, No. 11 - November 1974	**Available**	**Vol. 4, No. 3 - March 1976**	***NYP**
Vol. 3, No. 1 - January 1975	**Available**	**Vol. 4, No. 4 - April 1976**	***NYP**
Vol. 3, No. 5 - May 1975	**Available**	**Vol. 4, No. 5 - May 1976**	***NYP**
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Vol. 3, No. 7 - July 1975	**Available**	**Vol. 4, No. 7 - July 1976**	***NYP**

* Not Yet Published

Please allow at least four (4) weeks for delivery.

Rosemary L. Pickart, Order Clerk

WANTED — October, November and December 1973 issues of ASTRONOMY. Must be in good condition; needed to complete set. Willing to pay any reasonable price. Write Robert Heath, 911 Timmons Dr., Tuscola, IL 61953.

WANTED — October, November, December 1973 and August 1974 issues of ASTRONOMY. Will pay up to $5.00 depending on quality; will include postage and clasp envelope. Write Mark Grezak, 14355 Richfield, Livonia, MI 48154.

INFORMATION WANTED — On astrophotography with 5" RFT and SLR camera; what sky objects to observe and photograph; methods of finding and observing; details on clock drive and speed control. Write Mike Voisin, 1211 E. Chippewa, Mt. Pleasant, MI 48858.

INFORMATION WANTED — On astronomy clubs (or persons wanting to start one) in the New Haven area. Write Stephen Cannon, 80 Skyline Dr., West Haven, CT 06516.

INFORMATION WANTED — On books and articles on extraterrestrial life, black holes, Apollo space missions, future NASA space explorations. Also wish to obtain star, moon, solar system, galaxy charts, and picture of Earth (all poster size). Write Rango Keshavan, 12 Leslie Rd., Worcester, MA 01605.

INFORMATION WANTED — On astronomy clubs welcoming 12-14 year old astronomy enthusiasts. Also correspondence from persons in 11-14 age bracket interested in starting an astronomy club in Bakersfield area. Write Robert Madsen, 100 Hume Ln., Bakersfield CA 93309.

INFORMATION WANTED — Plans for cold camera. Also for Schmidt camera or similar instrument that doesn't require Schmidt corrective lens. Write Lee Hammond, 4171 Marquis Way, Salt Lake City, UT 84117.

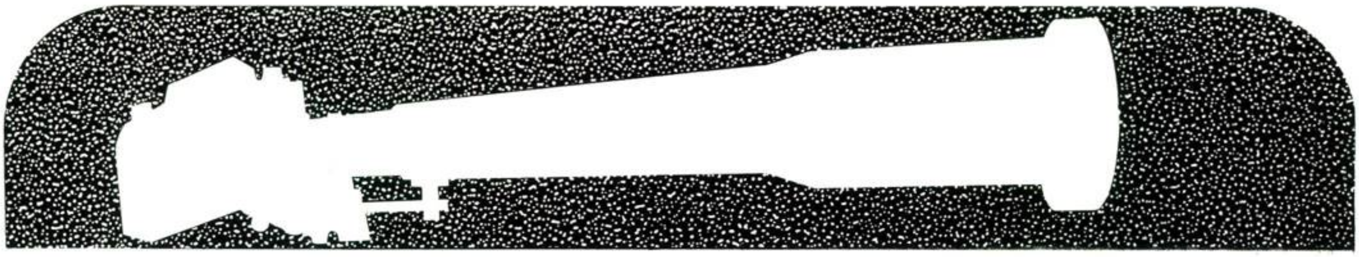
INFORMATION WANTED — On how to build a radio telescope. Write Thomas Kelly, 303 Church St., O'Fallon, MO 63366.

INFORMATION WANTED — Wish to get acquainted with other young adults in the Chicago area to share enthusiasm for astronomy or meteorology. Contact Larry Nudelmann, Loyola University, 6525 N. Sheridan, Chicago, IL 60626. Phone (312) 973-1419.

INFORMATION WANTED — About portable 12-1/2" reflector design (to be towed by auto). Attention should center on framework, jacking, shock absorption, and prevention of optical damage by road dust, etc. Write Terry N. Trees, 521 Isabella St., Apt. #3, Oakmont, PA 15139.

INFORMATION WANTED — On number of Wolf sunspot numbers per year from 1964 to 1974. Please state source of information. Write Mike Yakopovich, 1705 Brown St., New Castle, PA 16101.

INFORMATION WANTED — On formulas for astronomy, mathematics and planetary movement. Also addresses to mathematical associations. Contact Fred Young, 2951 138th Pl., Burnham, IL 60633. Phone (312) 868-2246.



PHOTOGRAPHY IN ASTRONOMY

Five Special Cameras
Part 1

by

Leo C. Henzl Jr.

Astronomical photography by nonprofessional astronomers has become so widespread in the last decade that it probably ranks as the astronomy enthusiast's most common pursuit apart from normal visual observation of celestial objects. Such endeavors as sketching lunar or planetary features or recording estimates of variable stars or even telescope making have been superceded by the desire to record sky objects on film.

A plethora of commercial equipment is available for this pastime, ranging from relatively inexpensive 35mm cameras to highly specialized cameras solely for astronomical use. These special cameras will be the focus of a two part in-depth study beginning this month. Five cameras were selected either because they are new or because their potential has not yet been exploited by the great majority of astrophotographers.

In this article, the Polaroid SX-70's application to sky photography is discussed along with the Celestron Schmidt camera. In October *we will review the DOAA Enterprises PLS camera, the Celestron-Williams Cold camera, and the Miranda Laborec camera.*

The Lagoon and Trifid nebulae are among the summer Milky Way's impressive collection of stars, dust and gas. The color recorded in this 45 minute High Speed Ektachrome exposure is not seen visually although both these objects are easily found with small telescopes. Photos like this represent the significant advance in celestial photography that has been achieved by the introduction of small aperture Schmidt cameras. This particular photograph was taken with an eight inch Celestron Schmidt camera.

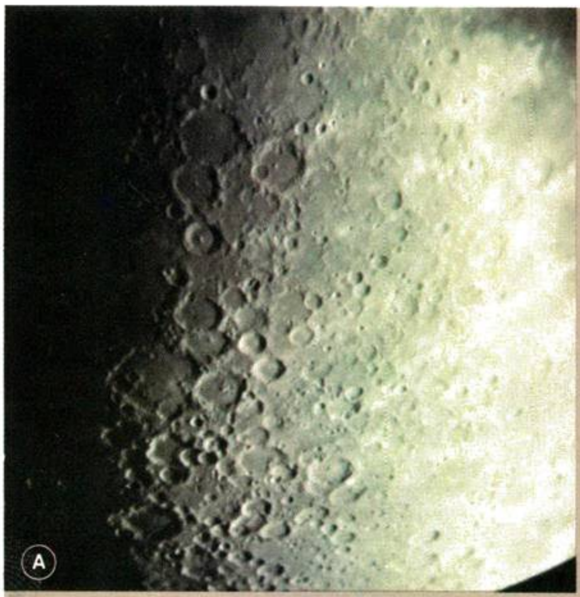
Photograph by Hans Vehrenberg

The Polaroid SX-70

Press the remote control push buttons and (click, whir, snap) the Polaroid SX-70 camera, astrophoto-adapted by R. T. Little Enterprises, ejects a piece of film. The photo's appearance is none too promising at first, but gradually, from the initial gray of the 3-1/8 inch square picture area, an image takes shape before your eyes. A few minutes more, and you have in your hands a glossy color portrait of a planet, the moon, or the sun.

Astrophotography aside for the moment, the SX-70 itself is laden with features and employs photo technology that might seem at first to border on magic. (Indeed, one is sorely tempted to utter a few incantations as the image forms — to help the process along — but this has been found to have little, if any, effect on the final outcome.)

The camera's design is beyond the scope of this article (and has been fully treated in various photographic journals during the past few years). Briefly, though, for readers unfamiliar with the SX-70, its really unique aspects are instant color snaps *plus* single lens reflex (SLR) design, executed via an ingenious system of variously angled moving mirrors for viewing and taking. The viewfinder provides an uncommonly bright focusing image — approximately 75 percent life size. The shutter is electronically operated, and the film transport system is driven by an electric motor. Obviously, all this (and flashbulb operation besides) requires a fair amount of electrical power, which is supplied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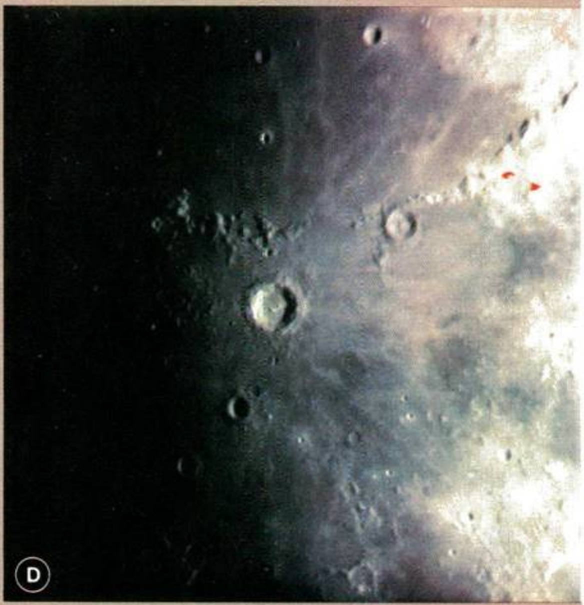
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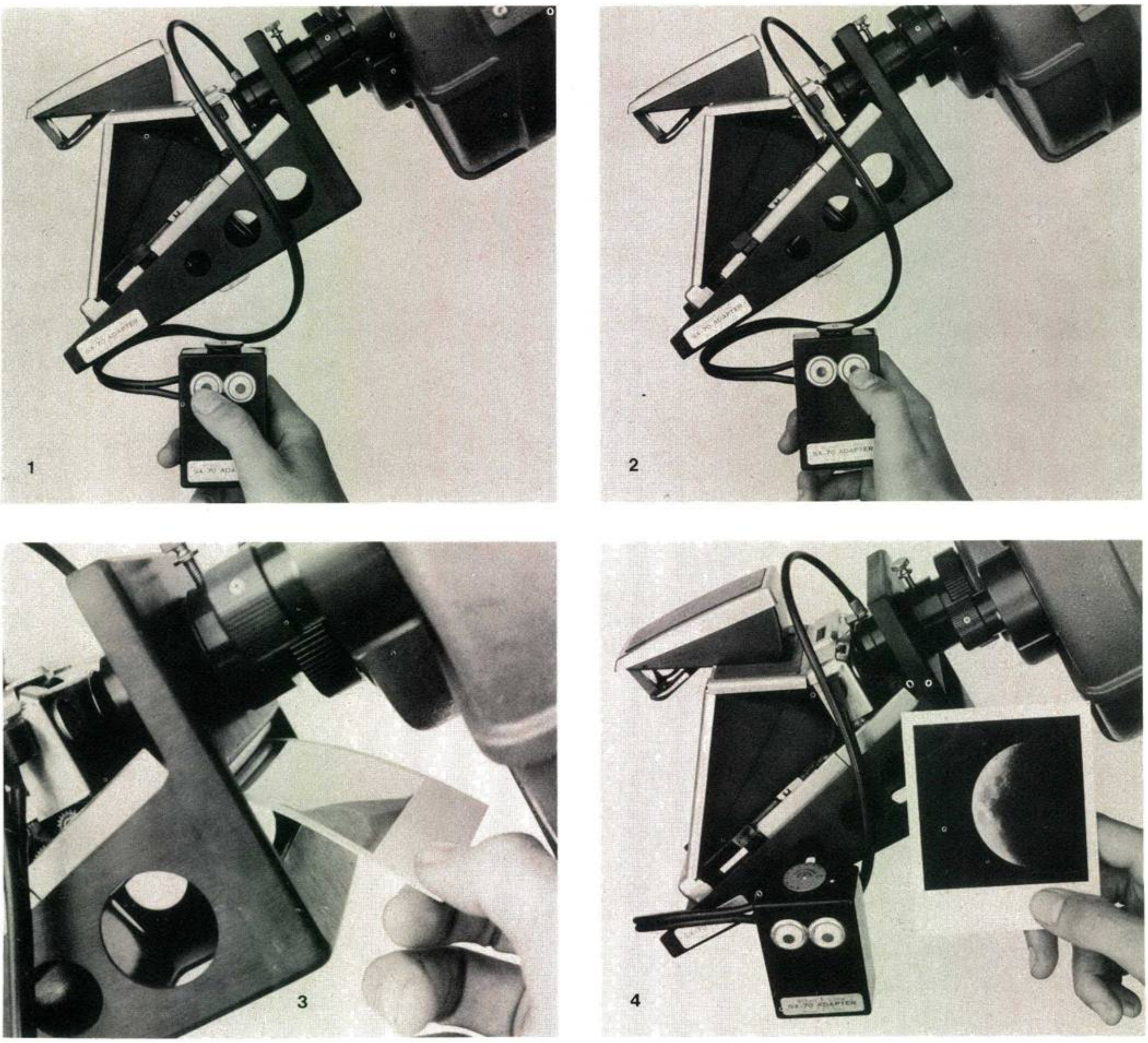


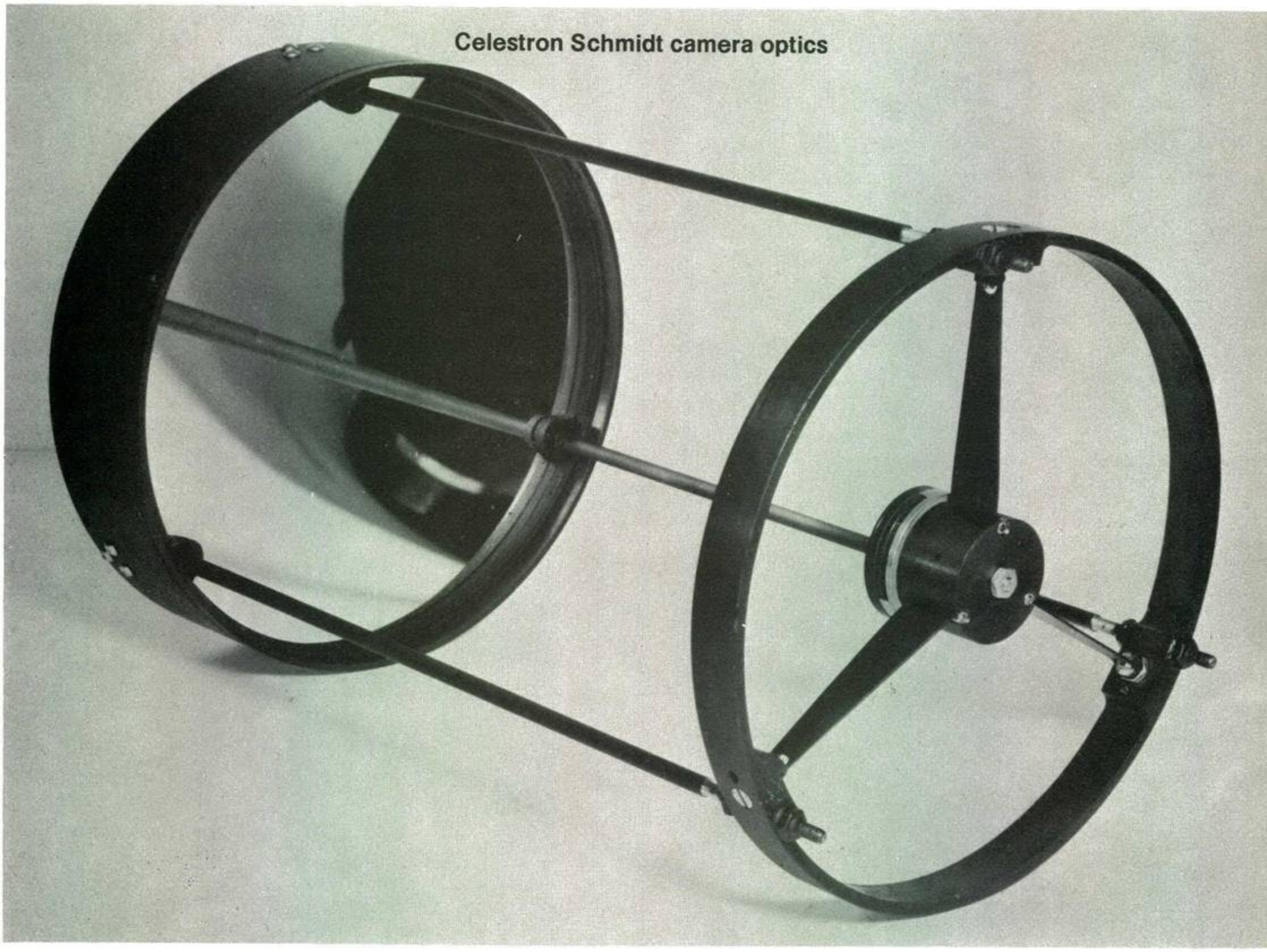
The Polaroid SX-70 camera easily attaches to a Celestron or several other telescope brands using the R.T. Little adapter kit. Displayed here is the sequence for shooting a finished astrophoto: 1) press green button to trip shutter; 2) red button closes shutter, terminating exposure; 3) film ejects through slot, and 4) finished print develops to completion in 10 minutes.

by a high output battery built into each 10 exposure SX-70 film pack. The film, too, is a departure from prior Polaroid products. Everything required to yield the positive color image is contained in the single piece of material the camera ejects — nothing to peel apart or discard. The SX-70 is available in two single lens reflex editions: a higher priced Model 1, and a lower priced Model 2. The differences are strictly cosmetic, with internal construction functionally identical — so either is satisfactory for use with the R. T. Little adapter system. (A less expensive Model 3 has also been introduced recently — but it is of nonreflex design, and has no application here.) Despite its complexity, the SX-70 folds into a neat, compact package (only 1-1/2" x 4" x 7"), and weighs less than many 35mm SLRs.

For astrophotography, the SX-70's most obvious virtues are reflex viewing and (almost)

These Polaroid prints demonstrate the SX-70's astrophotographic abilities over a wide range of subjects.
A) The southern lunar highland, 1.5 second exposure using a 14 inch Celestron with a 20mm ocular.
B) The moon's Apennine region — two second exposure on a 14 inch Celestron with a 20mm ocular.
C) Eight day old moon, 3/4 second exposure using eight inch Celestron with 28mm ocular.
D) Lunar crater Copernicus, three second exposure using 14 inch Celestron with a 16mm eyepiece.
E) Jupiter — a five second exposure through a 14 inch Celestron with 9mm eyepiece.
F) Prominences on a partial solar disc — a two second exposure through an eight inch Celestron equipped with a 40mm eyepiece and Skyspear solar filter.

Photographs A - D by Leo C. Henzl Jr.
Photograph E by Robert Little
Photograph F by Edward Hirsh



Celestron Schmidt camera optics

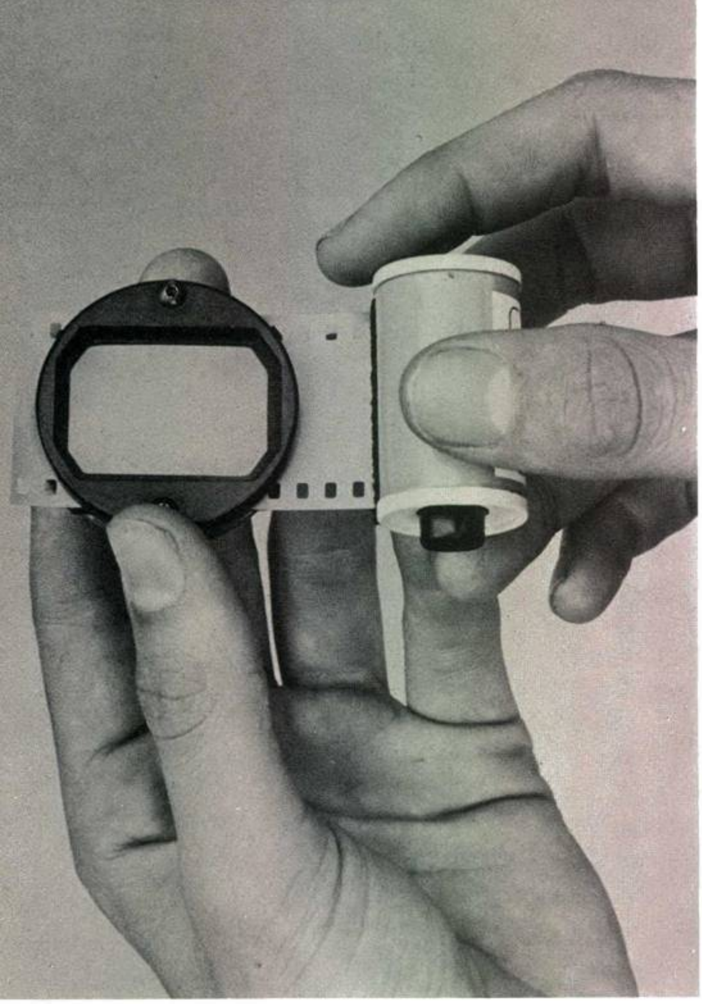
instant verification of results. Though the image may require 10 minutes or more to develop fully, the process is far enough along to judge results in a few minutes. Did your drive slip while the shutter was open, or was exposure less than perfect? No problem: Compensate accordingly and shoot again. How wonderful to know in minutes if your efforts have been successful — and what a boon this could be to school astronomy programs!

The Little adapter kit for the SX-70 consists of two basic parts: *1)* an aluminum mounting bracket and choice of fittings compatible with Celestron or Questar camera hardware, or any telescope employing 1.25" O.D. oculars, and *2)* a handheld electronic shutter control, which overrides the SX-70's automatic exposure system. Because the SX-70's lens (a 116mm, f/8.0 optic) is nonremovable, the camera must be used *afocally* for photos through a telescope — so a variety of oculars is desirable to achieve the effective focal length (EFL) required for a particular subject.

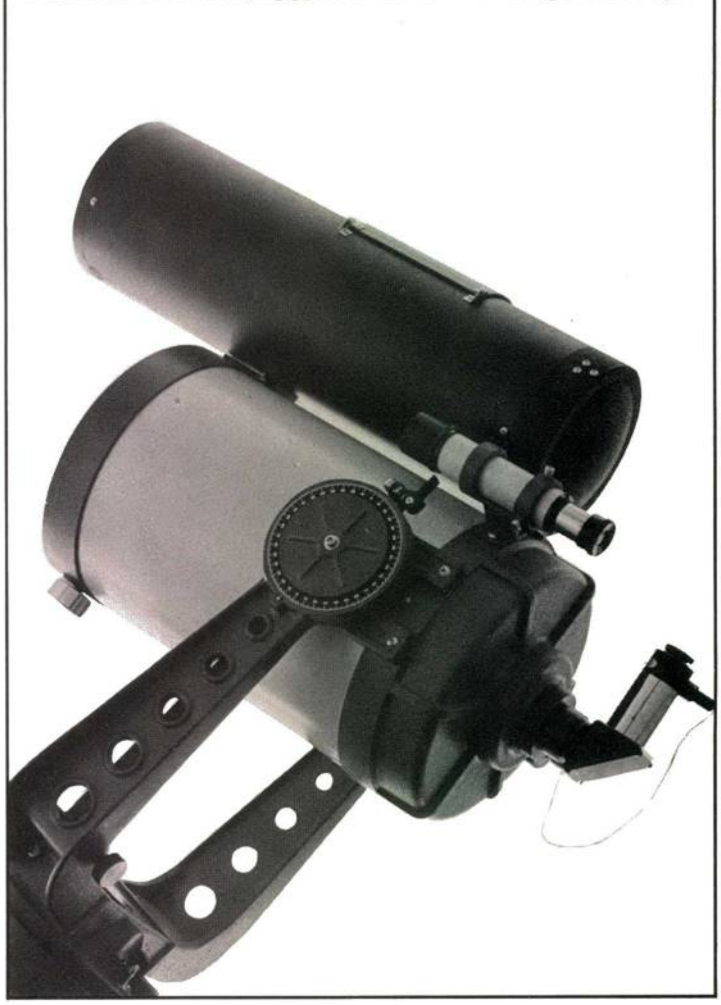
An afocal system EFL is the simple product of a telescope's visual magnification times the EFL of the camera lens employed. (For a more complete discussion of the afocal system and computations involved, see Photography in Astronomy, May 1975.) With the SX-70's 116mm lens system EFLs run from about 2,000mm to 75,000mm with typical amateur telescopes. If these seem a mite on the "long" side, bear in mind that the SX-70's film dimensions are 80mm square — more than seven times the area of a 35mm negative. Thus, the full moon still "fits" the frame at an EFL of 8,000mm. Images of planets tend to look a bit lost in a frame of this size, but SX-70 film is very fine grained, and thus stands up nicely to subsequent copying and enlargement. Polaroid Corporation also offers a slide making service for SX-70 prints wherein the full frame is copied onto a square of transparency film mounted in a standard 2" x 2" slide mount, so the final image size on your projection screen is nearly identical to what you'd have with 35mm film shot at the same EFLs.

Using the SX-70 is simplicity itself — and enjoyable enough that one is always tempted to "blow off" a few extra frames just for fun. Once the camera is mounted to the telescope in conjunction with a suitable ocular, and your object is focused and framed, you have two options for exposure control. In most cases, for exposures from about 1/2 second to the SX-70's 14 second automatic maximum, you'll simply press the remote control's

Schmidt camera film holder



5.5 inch Schmidt piggybacked on 8 inch guidescope



green button to start, and red button to stop. If, however, your object requires a shorter exposure, you also have the option of presetting the exposure time with a calibrated knob on the remote control box. Pressing the green button still starts the exposure, but it stops automatically at the preset fractional second interval.

For purposes of exposure determination with relatively bright objects, SX-70 film may be treated as ASA 75 or so. Among the drawbacks to this setup, though, is severe reciprocity failure with objects of low illumination. As the accompanying photos illustrate, the camera is eminently well suited to quick snaps of the sun, moon and planets, but impractical for constellations, aurorae, and other subjects which require a fast lens and high effective film speed.

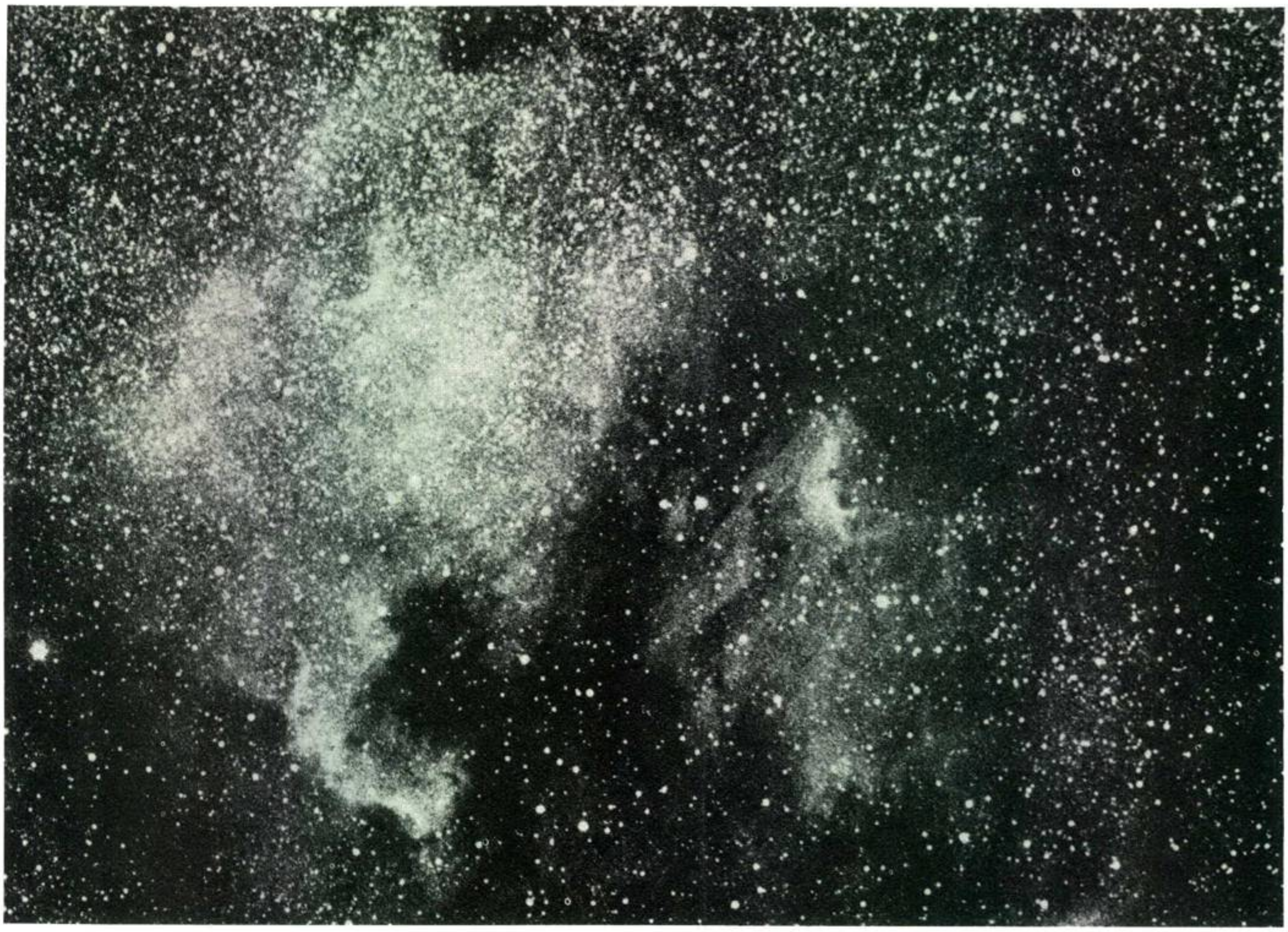
Are there other drawbacks? A couple, yes — but they're not difficult to live with. One is that the SX-70's recoil, when it goes off, makes the vibration of a 35mm SLR seem trivial by comparison. With a portable telescope, exposure control is definitely a job for the "black hat" method. And since the film was designed to self-develop at room temperature or higher, you'll have to forgo the pleasure of watching the image appear during the winter. Good practice is to keep a heating pad handy or put the film into a warm pocket while it develops. High summer temperatures seem to have no adverse effects, and the film maintains its excellent color rendition over a wide temperature range.

The Little kit comes nicely packaged for $125 with instructions and recommended exposure times for various subjects. For complete data and prices, write R. T. Little, Box E, Department LH, Brooklyn, N. Y. 11201.

The Celestron Schmidt Camera

In many ways, the Celestron Schmidt camera(s) is the antithesis of the Polaroid SX-70. It has neither a focusing mechanism, film transport or shutter assembly — in fact, it has no moving parts at all. It was designed to do one very specific job, and do it well: Record relatively wide angular sweeps of sky with (a) the shortest possible exposure time, and (b) a total absence of significant aberrations across its entire photographic field.

The basic Schmidt camera design has been around since 1930, when an unknown European optician, Bernard Voldemar Schmidt, first constructed a 14 inch camera with a then-unheard-of



Photograph by James L. Matteson

The North America nebula and the Pelican nebula reveal their intricate detail in this 25 minute Kodak 103aF photo through a Celestron 5.5 inch Schmidt camera. Enhanced contrast was achieved by the use of a Kodak Wratten #29 red gelatin filter.

f/1.7 focal ratio. The instrument was built in response to the need for increased recording efficiency in astrophotography. Prior to that time, deep sky photography had been a tedious affair — often involving exposures so lengthy as to require several successive nights for completion. "Revolutionized" is not too strong a term for what the Schmidt camera has since done for astrophotography and astronomy in general. It is probably safe to say that this device is responsible for more of what we know about our universe than any other single piece of equipment at the astronomer's disposal. Its wide field and extremely low f-ratio have uncovered cosmological relationships that might have taken centuries to adduce with pre-1930 photographic techniques — clusters of galaxies, for example, and even clusters of clusters. The same qualities also suit it perfectly for survey work: Objects deemed worthy of further investigation on wide field Schmidt negatives are the astronomer's guide in budgeting the limited research time available to him at the giant telescopes.

The principle of the Schmidt camera is basically simple. It consists of only two optical elements — a primary mirror and a Schmidt corrector plate. The mirror is of spherical curve — an optical "figure" which, if used by itself, would produce images distorted across its field by the optical defect known as *spherical aberration.* Spherical aberration is normally corrected out of an optical system by asperizing one of the imaging elements in a reflective system — the most common case being the parabolic surface on a Newtonian telescope's primary mirror. Unfortunately, this results in *coma* — an aberration which increases in severity with increasing distance from field center. It is the potential uniformity of

The whisps and contortions of the Eta Carinae nebula can neither be seen nor photographed by observers in the United States. At declination -59 degrees, the nebula is only easily seen from well south of the Tropic of Cancer. This 30 minute eight inch Schmidt camera photo on High Speed Ektachrome may be compared with the 60 inch Schmidt photo of the same object on page 12 of the June 1975 issue.

Photograph by Hans Vehrenberg

Despite its unimpressive visual appearance, comet Kohoutek was a fine subject for astrophotography. The wide field of the Celestron 5.5 inch Schmidt camera captures the entire sweep of the comet's filamentary tail in a three minute exposure on High Speed Ektachrome.

Photograph by Dennis di Cicco

MacLean Observatory Photograph

Nestled in a field of thousands of stars, the Dumbbell nebula is a gaseous celestial smear easily seen in small telescopes. This photo, taken through a Celestron 14 f/1.7 Schmidt camera, is a 15 minute exposure on Fujichrome R-100 film.

aberration in a spherical mirror that makes it an attractive choice for a wide field camera. In its most simple terms, the function of the corrector plate's complex figure is to introduce a sort of "inverse spherical aberration" as light enters the instrument — the net result being, as one cancels the other, zero aberration at focus. The image thus formed comes to focus in a curved plane, so a specially figured film holder is required to bend the film into conformity with the Schmidt camera's focal plane.

For many years, the marvelous potential of the Schmidt camera was available only to the professional astronomer or very skilled amateur optician. Now, however, Celestron Pacific offers three production models, priced within the means of serious amateur astrophotographers or small institutions. All three cameras are similar in mechanical design, differing mainly in aperture and focal length. The three models are:

1) A 5.5 incher of f/1.65 focal ratio. This instrument uses 35mm film and provides a field coverage of 5.9 degrees by 8.6 degrees. The camera is supplied with mounting hardware for pretapped holes in the Celestron telescopes, but its modest six pound weight suits it nicely to piggyback mounting with any reasonably sturdy, medium aperture telescope for guiding.

2) An eight incher of f/1.50 focal ratio, also using 35mm film for a field coverage of 4.5 degrees by 6.5 degrees. The 13 pound weight of this model requires a fairly large instrument of rigid construction for piggybacking, but it may also be mounted in the fork-and-drive base assembly normally supplied with the Celestron 8 Schmidt-Cassegrain telescope. In the latter case, an auxiliary telescope is required for guiding.

3) A 14 incher of f/1.7 focal ratio. This instrument is supplied with film holders for 35mm film —

Nearest of all galaxies, the Large Magellanic Cloud (it was called a cloud before its true nature was known) is 16,000 light-years distant. This sprawling city of about six billion stars is sprinkled with gigantic emission nebulae — the largest clearly seen in this 30 minute eight inch Schmidt camera photograph taken on High Speed Ektachrome.

Photograph by Hans Vehrenberg

providing a field of 2.3 degrees by 3.2 degrees — and for 120 size film, with a field coverage of 5 degrees by 6.5 degrees. Its 64 pound weight renders the 14 incher unsuitable for piggybacking on any but professional quality telescopes of very large aperture — but again the camera may also be installed with a separate guide telescope in the fork mounting normally used for the Celestron 14 Schmidt-Cassegrain telescope.

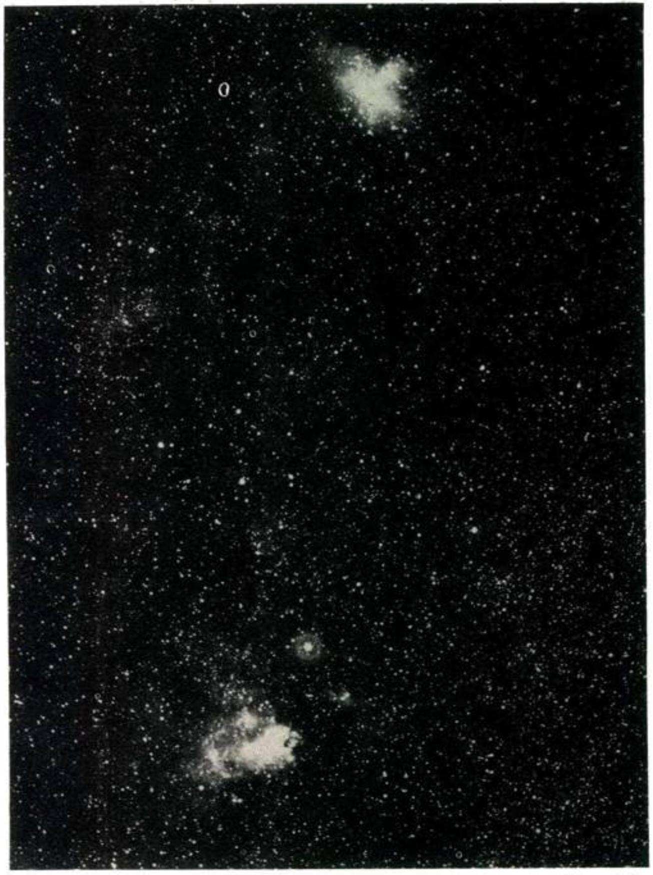
What's involved in using one of these sophisticated devices? Not much really. The cameras are factory-preset for exact infinity focus and the materials used in construction are of extremely low thermal coefficients, so that perfect focus and optical collimation are maintained over the entire range of typical winter and summer temperatures. Field coverage is such that locating a suitable guide star is never a problem. With the short exposures an f/1.5 or so system requires, a single night's work could produce a complete deep sky folio!

The main trial facing a beginner is the use of individual pieces of 35mm or 120 size film. With the Schmidt's curved film plain, single frames cut to size must be loaded into the camera via a hinged access port, and powerful magnets then secure the film holder, which has lugs for horizontal or vertical orientation. Care must be taken to avoid film scratches in loading and unloading, as well as in processing. Obviously, with single "chips" of film, you must be prepared to do your own black-and-white or color developing. The chips are usually loaded onto a spiral design plastic or nylon developing reel, with subsequent processing as usual in a daylight type developing tank. With a little care and practice in loading, a half dozen chips can be processed simultaneously on a single reel.

With the extreme photographic "speed" of a Schmidt system, exposure times are short even with relatively slow, fine grain films. Seldom will any object require more than 20 minutes. In locations of high ambient light where sky fog might prove problematic, the correct choice of red filter and red-sensitive film, used on a special filter retaining film holder (available from Celestron), will suppress sky light but allow the reddish light of nebular emission to pass unimpeded to the film.

Though the Schmidt camera was originally designed to record wide field subjects — extended nebulae and star fields — the extreme resolution and optical speed also makes it practical to shoot small scale subjects with such superfilms as H & W VTE or Kodak SO-410 — extremely fine grain emulsions of high contrast but relatively low speed. Schmidt negatives from these films tolerate enlargement ratios of 50 times and more, so that the net detail and image size of a small nebula on the final print from — say — an eight inch Schmidt camera, with its 12 inch EFL, is more what you might expect from any ordinary optical system with an EFL on the order of 40 or 50 inches. Any color film suited to home processing may be used in the Schmidt, with the slower, finer grain transparency films being better matched to the system's potential resolution.

Much more could be said for these marvelously versatile deep sky cameras, but the accompanying photographs speak for themselves. Celestron offers a free, lavishly illustrated booklet on the Schmidt photography. To obtain your copy, write Celestron Pacific, 2835 Columbia St., Box 3878-LS, Torrance, Calif. 90503.



Photograph by Leo Henzl Jr.

In the densest portion of the Milky Way, some outstanding deep sky objects are close enough to each other — from our point of view — to be photographed in the same field with a Schmidt camera system. Here M-16 (top) — the Eagle nebula — lies just north of M-17, the Omega or Checkmark nebula. Both objects can be seen as faint wisps in very small telescopes. The photograph is a 15 minute exposure on Kodak 103aF film using an eight inch Celestron Schmidt camera.

The compact galactic star cluster NGC-6231 (near Zeta Scorpii) is centered in this eight inch Schmidt camera photo on High Speed Ektachrome. The whisp of nebulosity seems to be associated with the more scattered star cluster H12 nearby. This area is one of the most star filled zones of the Milky Way.

Photograph by Hans Vehrenberg

Antares' reddish-orange brilliance is a dazzling contrast to the subtle glow of a ball of distant suns known as M-4. Although over 10,000 light-years away, M-4 is one of the nearest globular clusters. This 30 minute exposure on High Speed Ektachrome was taken through a Celestron Schmidt camera.

Photograph by Hans Vehrenberg

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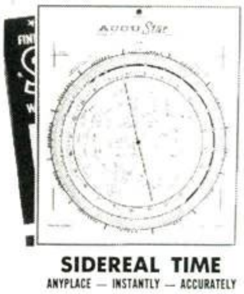

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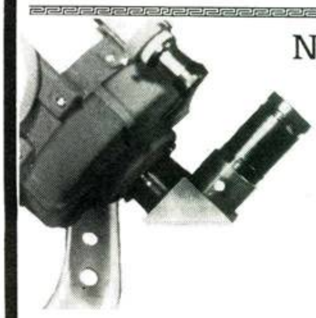

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ASTRO-NEWS

Latest News From the World of Astronomy

Pioneer 11 Finds Complex Jovian Magnetic Fields

Data from the Pioneer 11 spacecraft that visited Jupiter last December suggests that this huge planet's magnetic field is much more complex than previously thought. Earlier measurements made by Pioneer 10 (which flew by Jupiter a year before Pioneer 11) indicated a relatively simple magnetic field having only one north and south magnetic pole, much like Earth's.

Scientists believe that planetary magnetic fields are produced by internal motions of liquid materials by mechanisms similar to those of electric dynamos. Earth's field probably emanates from a core of molten iron and nickle-iron, and Jupiter's field from liquid or metallic hydrogen.

By flying three times closer to Jupiter than Pioneer 10, Pioneer 11 discovered that Jupiter's interior may contain a large ring current or generator, along with many eddies or smaller generators — rather than a single large one. Pioneer experimenter Walker Fillius of the University of California, San Diego, points out that such a complex field close to the planet would be required to explain the field's observed high energy particle pattern, as well as the bursts of intense long wave radio energy radiating from Jupiter.

Wobbling and tilting like a plate on top of a juggler's stick, Jupiter's field sometimes stretches across nine million miles of space, and at other times shrinks in volume by 3/4 or more. Inside this pulsating field are the belts of intense radiation. Electrons trapped there are 10,000 times more intense than those in the Van Allen radiation belts girdling Earth, and their energies range upward to more than 30 million electron volts. Protons, the nuclei of hydrogen atoms, are also trapped near Jupiter.

Pioneer 11 found that peak intensities of high energy electrons were moderately higher than Pioneer 10 experienced. Similarly the peak proton intensity experienced by Pioneer 11 was 100 times stronger than that encountered by Pioneer 10. But these very high energy protons were concentrated in small, shallow regions. Pioneer 11 sliced through these narrow regions so quickly — at a record speed of 107,000 m.p.h. — that it received relatively low total radiation.

Neither the Pioneer 11 spacecraft nor its scientific instruments suffered damage in the belts, although radiation particles produced effects which resulted in dozens of false commands to some of the instruments, temporarily interfering with their operation and causing some loss of data.

Trojan Asteroids Unusually Dark

A recent study of a distant group of asteroids reveals that they are the darkest known objects in the solar system. These little studied objects, known as Trojan asteroids, are locked by Jupiter's gravity into clusters that both precede and follow the giant planet.

The first of the 30 known Trojans was discovered in 1906 during a photographic search for "normal" asteroids that orbit the sun between Jupiter and Mars. Their existence in clumps 60 degrees ahead and behind Jupiter proved a mathematical theory developed in 1772 which predicted such positions of stability.

Until the recent discovery, the Trojans were believed to be similar in composition to normal asteroids, and less than 50 miles in diameter. Now Dale Cruikshank of the University of Hawaii has found that three Trojans reflect back only three percent of the sunlight that reaches them. This means they are virtually black and made of some dark and as yet unknown material.

Previous diameter estimates had to be revised with this finding. Hektor, the largest Trojan, is now believed to be 150 miles in diameter — which places it among the 10 largest asteroids. Aeneas, another major Trojan, is 110 miles wide, while Anchises (the third asteroid of the group that Cruikshank measured) is 75 miles across according to the new study. The smaller two Trojans follow Jupiter, while Hektor precedes the big planet.

Using the 88 inch telescope on Mauna Kea in Hawaii, Cruikshank recorded the infrared radiation from these asteroids. The results are based on the assumption that a dark object absorbs more sunlight than a light one and hence will radiate more of that absorbed heat as infrared radiation.

Estimates place the total number of Trojan asteroids at more than 1,000 — with most of them less than a mile or two in diameter. Because their distance from Earth is the same as Jupiter's (never less than about 400 million miles), the Trojans are too faint to be seen in small telescopes. Hektor, the brightest, is 14th magnitude or about 5,000 times fainter than the faintest stars the unaided eye can detect.

Interest in the Trojans and other asteroids is soaring because it is felt they may hold clues to questions on the origins of the planets — questions that remain unanswered after analysis of the moon rocks.

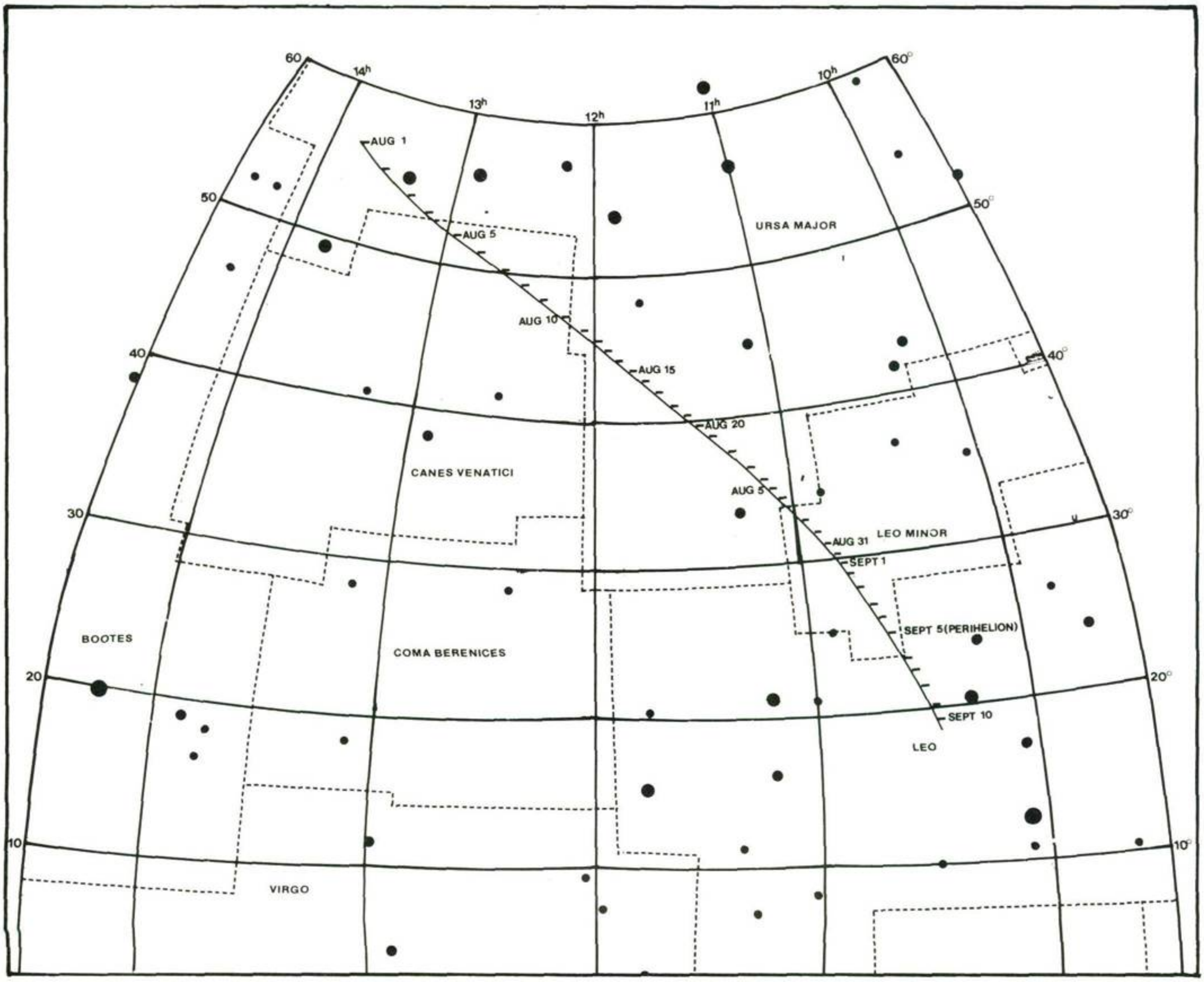
New Comet Coming

Early in July a new comet was discovered moving swiftly through the constellation Aquarius. To bring our readers the latest news concerning this unexpected visitor, ASTRONOMY has delayed publication to include the following photographs and reports.

By present estimates, comet Kobayashi-Berger-Milon (1975h) will be best visible as a naked eye object during the first two weeks in August. Past midmonth, the comet will become lost in the evening twilight as it streaks toward a Sept. 5 perihelion pass of the sun. Current estimates place the comet's maximum magnitude at +4.0.

"It's not intrinsically a very bright comet," reports Brian Marsden of the Smithsonian Astrophysical Observatory. "The comet seems bright now only because it happens to be near Earth." Marsden does not expect much tail development.

Marsden points out 1975h's orbit is similar to that of comet 1903 IV. He does not believe they are the same comet, but perhaps members of a particle group following the same orbit. Marsden speculates such a group could be debris from an unknown large comet that once broke up.



60
14h
13h
12h
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AUG 1
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SEPT 5(PERIHELION)
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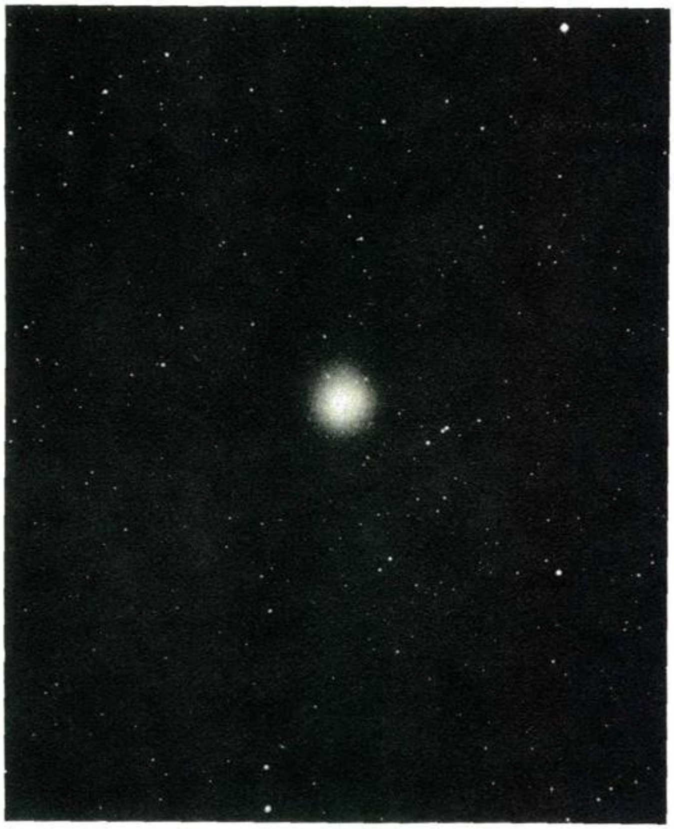


Photograph by Robert Provin

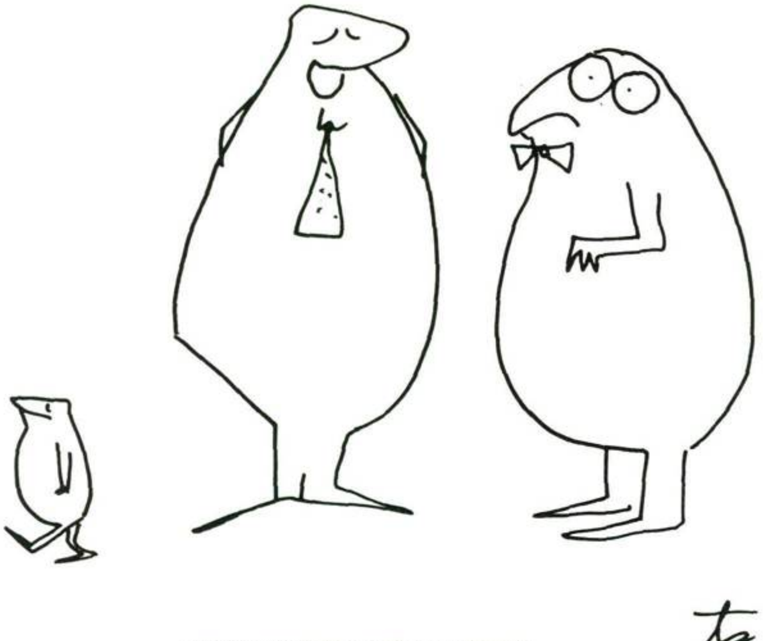
Table Mountain Observatory photograph

"This comet sort of sneaked up on us," says Marsden. Despite the fact that 1975h was a southern hemisphere object until early July, Marsden is surprised no professional astronomers first detected it; the elusive object apparently slipped by the Australian Sky Survey. On July 3, Toru Kobayashi of the Tokyo Astronomical Observatory telegraphed a "probable" comet discovery to the International Astronomical Union Telegram Bureau at the Smithsonian Observatory. Bad weather in Japan and uncertainty over which direction the comet was heading held up confirmation by Kobayashi. Because the comet was moving faster than expected, Marsden, meanwhile, had five observers unsuccessfully trying to confirm the Tokyo report. On Sunday, July 6, an independent discovery by Douglas Berger in California, and observations at Lick Observatory, finally confirmed the comet's existence. Dennis Milon's report arrived the morning of July 7.

Comet Kobayashi-Berger-Milon entered the solar system at an extremely high angle -- about 85 degrees. According to right ascension and declination predictions produced by Marsden and Steven Albrecht at the University of Wisconsin, it will course through Ursa Major, Leo Minor and Leo as it begins a rapid southerly journey. The comet will remain fairly constant in right ascension (about 10 hours 30 minutes), but move over a degree per day in declination as it leaves the solar system traveling through Sextans and Antlia in the sourthern skies beyond the reach of northern telescopes.

Initial reports from comet 1975h observers agree the visitor is a round, diffuse object with an almost starlike, condensed nucleus. Some discrepancy exists in the type of tail -- if any -- the comet has. Reports vary from no tail at all, to a short spike, to a fanlike projection visible in larger telescope apertures. All reports indicate this comet is not uncommon or unusual in any way.

Visual magnitude estimates vary from similar to the Andromeda galaxy to more like M-13, the globular cluster in Hercules. In any case, in a dark, clear sky, comet 1975h is definitely visible to the unaided eye, but probably won't brighten beyond magnitude 4.



"It's the latest in compact equipment — a 12-1/2-inch reflector with a 6-inch refracting astronomer."

Possible Laser Communication From Nearby Stars Investigated

For the first time, a satellite is being trained on nearby sunlike stars to search for signs that other civilizations may be trying to contact us with ultraviolet laser beams.

The satellite is NASA's Copernicus Orbiting Astronomical Observatory, whose telescope is scanning the stars Epsilon Eridani, Tau Ceti, and Epsilon Indi — all about 11 light-years from Earth.

Leading Earth's first intragalactic laser communication experiment is Herbert F. Wischnia, a consulting electro-optical engineer and guest investigator in the Copernicus program.

Wischnia scanned the first star — Epsilon Eridani — last November, and the data from Copernicus, transmitted back to Earth, is now being analyzed. The telescope was trained on the star for 14 orbits while the spectrometer scanned the UV spectrum for potential laser signals to Earth.

While the data from Epsilon Eridani are being analyzed, plans are underway to scan Tau Ceti and Epsilon Indi this summer and fall. These laser observations can only be made from a space observatory since Earth's atmosphere prevents UV radiation from reaching the surface.

Bits and pieces of evidence from astronomy, phsics and biology suggest that life is not a one-time accident in the universe — but that it can appear spontaneously in a favorable planetary environment and evolve into complex beings, provided vast amounts of time are available. Consequently, the possibility exists that Earth is being irradiated from space by signals from intelligent civilizations on Earthlike planets circling other suns.

The technical difficulties in detecting radio signals are related to knowing where to look and at what frequency to listen. Ultraviolet laser search experiments avoid this problem, according to Wischnia. He asserts:

"Stars with a temperature near that of our own sun radiate very little energy in the vacuum UV, so that the telescope receivers are not 'blinded' by natural stellar radiation. These reasons make the UV lasers rational candidates for intragalactic beacons."

Copernicus has been orbiting Earth since 1972 at a distance of approximately 450 miles, making precise astronomical observations of a number of celestial objects from a position above the atmosphere.

Yerkes Refractor Idled For First Time In 80 Year History

Yerkes Observatory's 40 inch refractor telescope has been idled for the first time in its 80 year history while the telescope's mammoth dome is replaced during July, August, September and half of October.

According to Kyle Cudworth, assistant professor of astronomy at the University of Chicago, replacing the 1895 dome was "absolutely essential and could not be delayed." The old dome was made of wood and metal over a steel truss frame, and water leaking between the plates had seriously damaged the observatory floor and risked injuring the world's largest refractor. An estimated 20 percent of the wood-metal structure was irreparable.

Stainless steel will replace the old dome, and during construction the 63 foot telescope will be housed in a wooden structure to prevent damage. No work is being done on the telescope during the construction period.

Since the 1890's, the Yerkes telescope has provided science with the biggest permanent tool for photographing stars and measuring their positions relative to other stars. In recent years, according to Cudworth, the instrument has been used for two basic programs — one measuring distances to faint stars, and the other measuring *proper motions* of stars (the apparent movement of a certain star against the stellar background).

A library of 150,000 photographs taken with the telescope (about 30,000 of which are used for proper motion determination) are irreplaceable because of age. (Proper motion is determined by comparing old photographs of stars with recent ones and measuring the distance the star has traveled in the time elapsed between photographs.) Some of the Yerkes plates were taken in 1900, making their comparison with recent photographs invaluable.

Suspension of operations with the big telescope will hamper research slightly, but Dr. Lewis Hobbs, director of Yerkes, said this will not harm the telescope's role in scientific research.

The University of Chicago, owner of the observatory, is handling the estimated $300,000 cost, with the University of Chicago Women's Board contributing $75,000 through a fund-raising venture. The repairs have been contracted to a Highland, Ind. firm.

Observing the Perseid Shower

by

Guy Ottewell

August is the month for meteors. The richest and most reliable meteor shower is known as the Perseids. At the height of its display on the night of Aug. 12-13, as many as 50 meteors per hour may be visible.

In past years the moon has spoiled the Perseid shower by flooding the skies with unwanted illumination. Not since 1972 have totally moonless skies accompanied the event's peak.

For most of the United States, the first quarter moon will set at about 11:00 p.m. local daylight time on the evening of the 12th. From then until you fall asleep will be the time to watch.

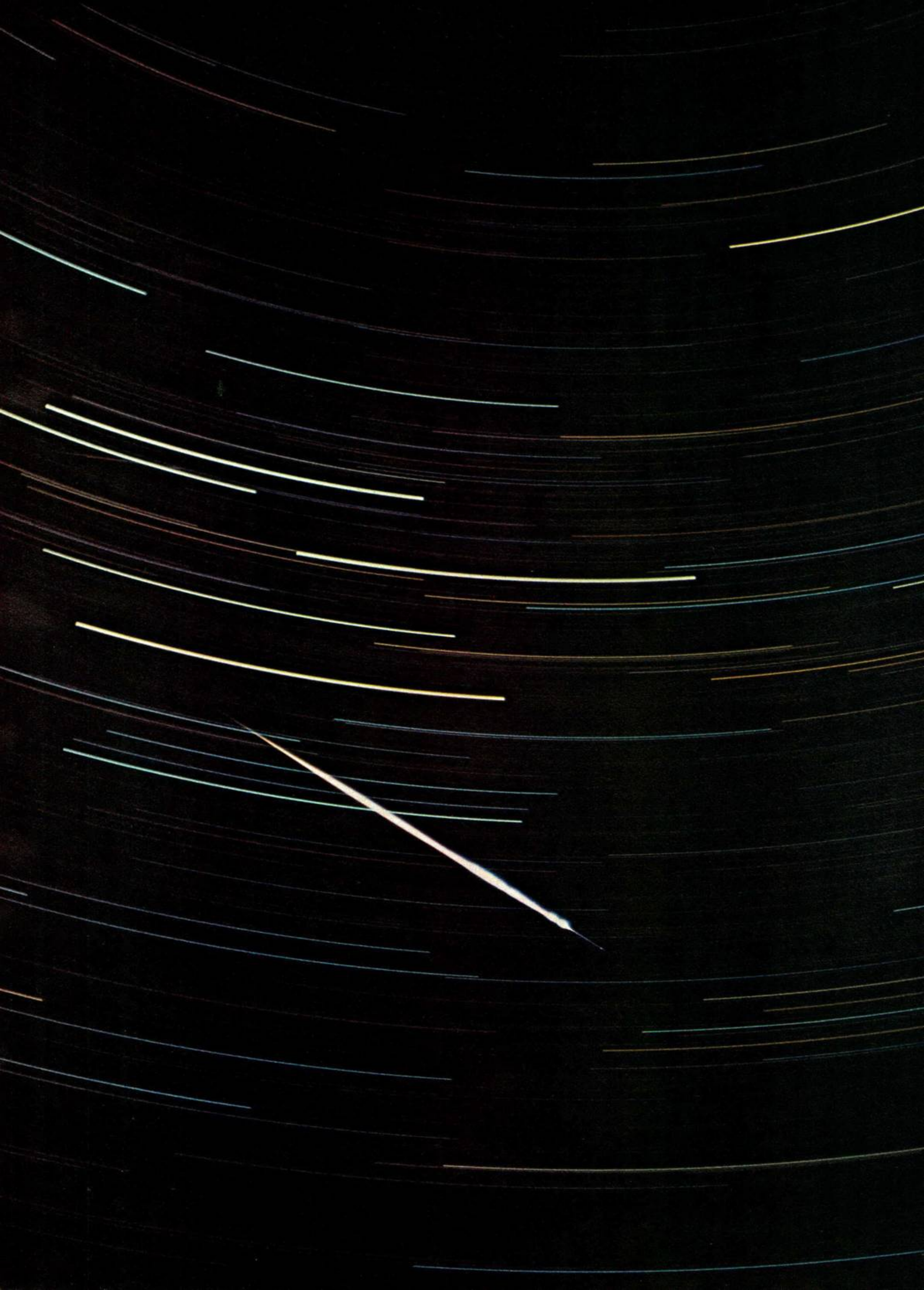
The Perseids did not always hold the title of "year's best shower". In the past, the now dying Draconids, Andromedids and Leonids were once spectacular. But the Perseids — in our time — are the most reliable; annually they offer much more to see than their usual rivals, the Orionids and Geminids.

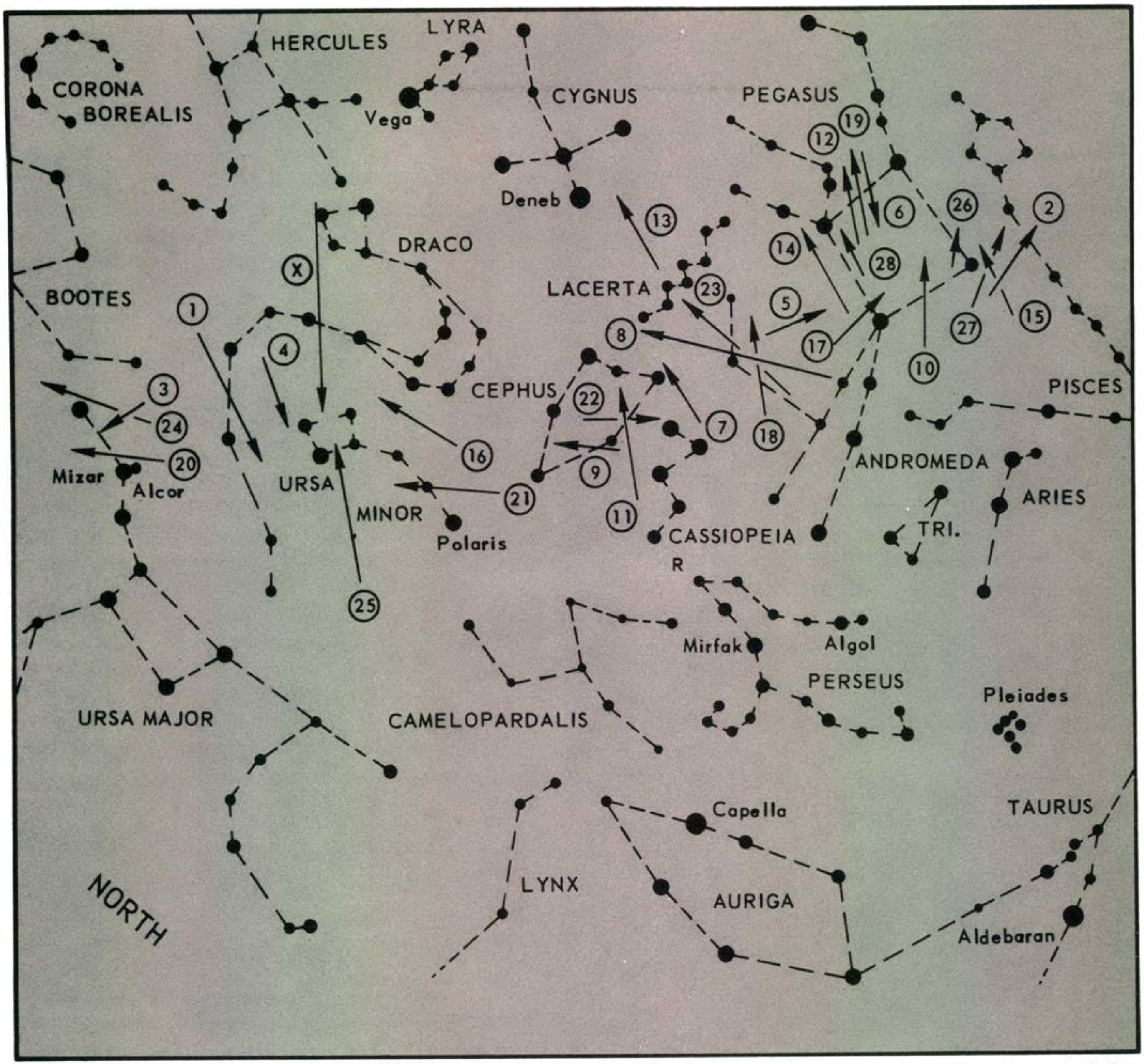
One reason for the steadiness of the Perseids is that their orbit comes down steeply through the plane of our orbit. Thus it does not pass near any planet other than Earth, and has not been much "perturbed" by the gravity of the other planets.

The particles have had time to spread quite evenly along the orbit of their parent comet (Swift-Tuttle). From counts of them, it has been estimated that their mass would add up to 500,000,000 tons. This, then, plus whatever mass the comet still has left, must have been its original mass.

The Perseids are swift; many are very bright; some divide like forked lightning, and a few leave trains for up to nine seconds — so they are a wonderful subject for photography. There is amazing variety in the descriptions that people give of the colors of Perseids: reds, oranges, yellows, green, and whites — all seemingly related (though in no very clear way) to the brightness.

When hourly counts are plotted as a graph, it reveals that the Perseids rise slowly toward their peak, and then quickly drop. This happens with some other meteor showers too. Another change which takes place each year during our passage through the broad Perseid stream is that its radiant moves eastward from night to night. This, too, happens with other showers. Its cause is that our orbit and the stream's orbit are both curved: As we move onward, particles in the stream meet us at progressively changing angles. But in




HERCULES
LYRA
CORONA BOREALIS
Vega
CYGNUS
PEGASUS
Deneb
DRACO
BOOTES
LACERTA
CEPHUS
PISCES
Mizar
Alcor
URSA MINOR
Polaris
ANDROMEDA
ARIES
CASSIOPEIA
TRI.
R
Mirfak
Algol
PERSEUS
Pleiades
URSA MAJOR
CAMELOPARDALIS
Capella
TAURUS
LYNX
AURIGA
Aldebaran
NORTH
X
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28

Chart by Steven A. Mackey

This chart represents two hours worth of Perseid meteors on the night of Aug. 10-11. Each meteor is numerically coded, telling its time, magnitude, color and any additional information. A large number of sporadic meteors has partially masked the characteristic radial shower pattern. The chart was produced by members of the Tacoma (Wash.) Astronomers, Inc.

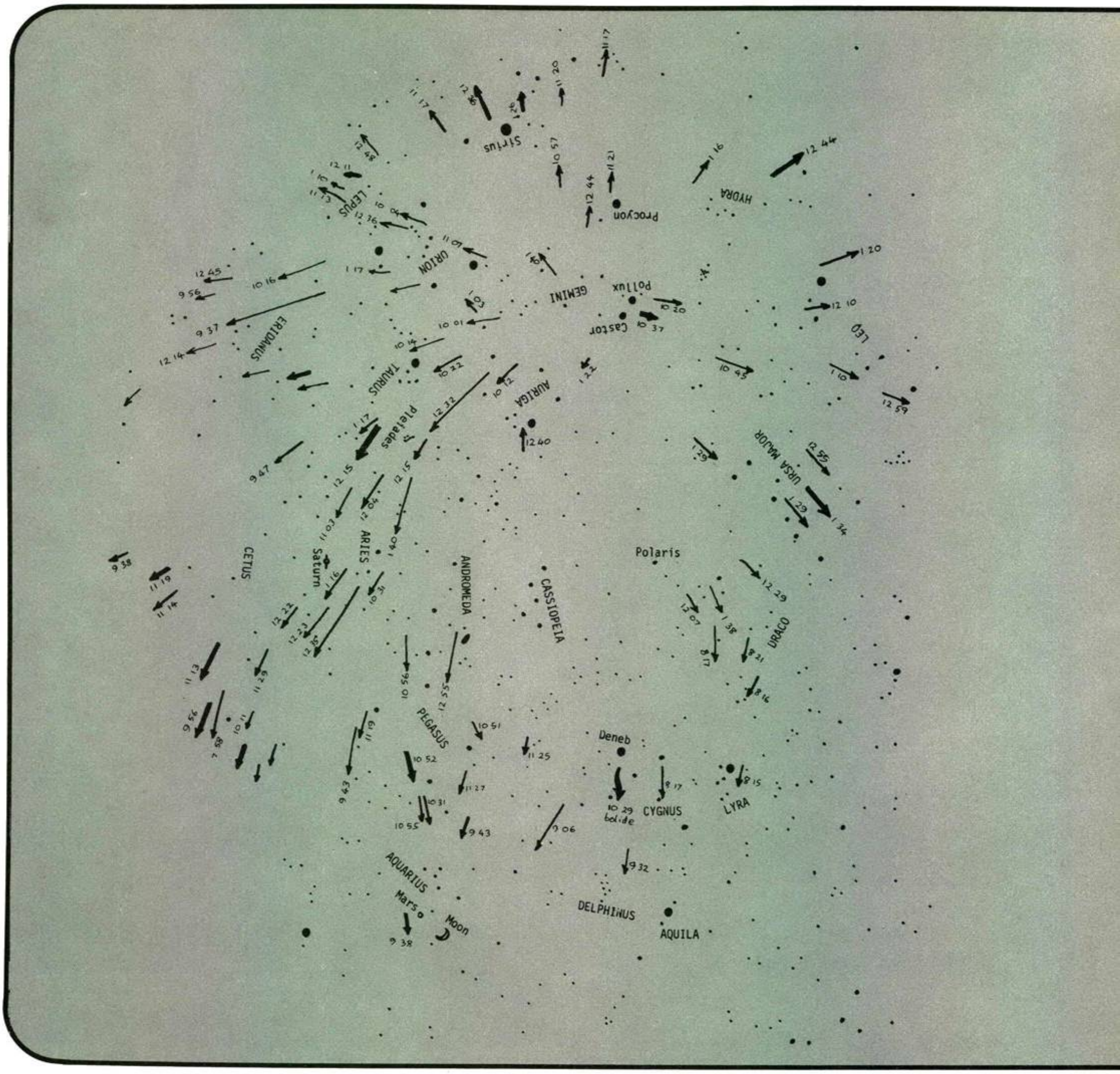
the case of the Perseids, this migration of the radiant is very great. When the first few Perseids appear toward the end of July, they are coming from near the Andromeda galaxy, far west of Perseus. By the climax of the shower on the morning of Aug. 13, they are coming from near the famous double cluster in Perseus; in the last few days (up to Aug. 18), the radiant moves out of the other side of the Milky Way into the obscure constellation Camelopardalis.

An exceptionally bright Perseid fireball meteor blazes past the constellations Andromeda and Cassiopeia on Aug. 12, 1972. The fireball was recorded with an f/2.8 exposure on High Speed Ektachrome film pushed to ASA 400. An ordinary 35mm camera with an f/2.8 lens or faster is ideal for meteor photography. Since time exposures are required, the camera must be mounted on a rigid tripod.

Photograph by Ronald A. Oriti

Though the Perseid radiant is far north in the sky, this does not mean it is always high in the sky. At this time of year, for people in North America, Perseus at sunset is very low on the northern horizon. The turning of the sky around the pole gradually carries it eastward, upward and westward, until about dawn it is practically overhead. Taking this consideration alone, then, we would expect the predawn hours to be best for seeing Perseids.

Scientifically the most useful thing for amateurs to do is to count the numbers of meteors seen per hour. Send the results to this magazine or any astronomical organization. Mention your name


Sirius
Procyon
HYDRA
LEPUS
ORION
GEMINI
Pollux
Castor
LEO
ERIDANUS
TAURUS
Pleiades
AURIGA
URSA MAJOR
Polaris
CETUS
Saturn
ARIES
ANDROMEDA
CASSIOPEIA
DRACO
PEGASUS
Deneb
CYGNUS
LYRA
10 29 bolide
AQUARIUS
Mars
Moon
DELPHINUS
AQUILA
12 44
1 20
12 10
10 45
1 10
12 59
12 40
12 55
1 34
12 29
10 16
12 45
9 56
9 37
12 14
9 47
9 38
11 19
11 14
10 01
10 22
12 32
12 15
12 04
1 40
10 31
10 56
12 55
10 51
11 25
10 52
11 27
10 31
10 55
9 43
9 06
9 32
9 38
8 17
8 15
8 16
8 21
12 07
1 38

and address, how much — if any — meteor observing you have done before, the location you observed from, a rough idea of the amount of light pollution there, the date of the observation, and the kind of clock time you used (Eastern Daylight, etc.). Then for each hour (9-10, 10-11, etc.), give the number of shower members seen (such as Perseids), the number of meteors which were not Perseids, and the conditions (cloudiness, for example). The way to tell which meteors were shower members is to see whether they pointed away from the radiant — so the minimum knowledge you need is to have read where the radiant is and to be able to identify the constellation it is in. If anyone else observed along with you, be sure that *separate* reports are made for each person.

From many reports like this, scientists can draw a graph showing when the peak of the shower occurred. If the exact date and time of this is established, it simultaneously establishes the point in space at which the orbit of the thickest part of the meteor stream crosses Earth's orbit. This in turn helps to establish the connection between the meteor stream and a comet, and also to predict exactly when the shower will occur next year.

If you could be on the part of Earth facing directly into the meteor stream — that is, if you were right underneath its radiant — you would see the *zenithal hourly rate* (ZHR). This theoretical maximum is reduced to the lower number you actually see because of six factors:

1) The moment when Earth crossed the center

Recording the Meteors

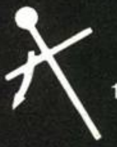
Meteor observing can be conducted either alone or as a group activity. The following is Guy Ottewell's description of a solitary session watching the Geminids on Dec. 13-14, 1969.

"That night, armed with my notepaper and a red-screened flashlight, I was nestled inside a sleeping bag on top of a lawn chair. Still, it was not a comfortable thing to do in midwinter at a height of 6,300 feet in the windy desert of Arizona! So I stopped at 2:00 a.m. when the shower was only just reaching its peak. But the 95 meteors I had seen enabled me to construct an interesting record the next day on a large map of the sky (reproduced here).

"Each arrow was the path of a meteor — the thicker arrows being bright meteors, and the numbers being clock times. The arrows seem to be deflected somewhat around the edges like fish swimming in a bowl, but this is because of the necessary distortion of any sky map; most of the arrows are in fact pointing fairly directly away from Gemini. A few are uncertain cases, and one (at 12:40 a.m.) is definitely a sporadic meteor, for it points *toward* Gemini.

"In the Aquarius region of the sky, only times early in the night are noted — because as Earth turned, this part was the first to set; in the Leo region, which rose into view while I was watching, only late times appear. If I had waited up past 2:00, there would have been other meteors to plot in Virgo and beyond.

"Plotting the meteors afterward is the easy — or at least the unhurried — part. But how does one log them at the time? At first I thought I could mark them in my star atlas with an arrow and key number, and write notes about each on sheets of paper prepared in advance — with columns for the key number, time, magnitude (brightness), color, speed, and other features such as whether the meteor split up or left a train (persistent streak). But soon I found that there was no time to turn to pages of the atlas, let alone write all these notes. Instead, I jotted a kind of shorthand like this —



10:29 bolide

— which meant that a meteor went through the constellation Cygnus at 10:29 p.m. It was a bright one — a bolide — with a wavy course. (I knew the constellations well enough to write my simplified versions of their shapes almost as quickly as letters.)

"Mapping like this is excellent exercise for your knowledge of the constellations, and gives you a comprehensive feeling of the great meteor stream pouring upon Earth. But it has little scientific value nowadays, because the radiants of the showers are being determined by more exact photographic means.

"An easier thing to do, if you have a camera, is to set it on a tripod and leave it open for an hour, pointing toward a wide area of the sky including the radiant. Stars will make curved arcs centered on the polestar; meteors will make straight lines pointing backward to their radiant. Use a fast film — although even then you will find that most meteors are too faint and cross too quickly to register on the film."

of the stream. It happens at the same point in Earth's orbit each year — but, since the year contains 365-1/4 days, it may occur one year when you have darkness.

2) The local time when the radiant is highest in the sky. This in turn is determined by two things: the right ascension of the radiant in the map of the sky, and the time of year. The radiant may be highest at about 5:00 a.m. (the time when you would be facing directly into the shower). Watching at midnight, you will not see so many meteors.

3) The highest the radiant can get in your sky. This is determined by its declination in the map of the sky, and your latitude on Earth. Observers around 40 degrees north latitude in the U.S. cannot see the greatest number of meteors from streams whose radiants are in the extreme north of the sky (like the Ursids) or the southern hemisphere of the sky (like some of the Aquarids).

4) The moon. If it is up and smearing the sky with light, you won't see many meteors.

5) The weather.

6) Your experience and alertness.

For the Perseids, the ZHR is 68. This is only an estimate since some observers have reported 100 meteors per hour near the peak. Of the factors listed above, #1 is off the optimum by several hours. The peak is predicted for 9:00 p.m. EDT Aug. 12 — about six hours earlier than we would like. Thus, we should not expect to achieve the top ZHR of 68. Consider yourself lucky to see 50 per hour, as conditions are rarely good enough even for that figure.

STAR DOME

AUGUST

Like a flickering lantern on the stern of some celestial "Flying Dutchman", red Antares glimmers as a spectacular member of the summer sky. Antares is easily found suspended low above the southwestern horizon, where no nearby stars mirror its splendor. Nor do any of the bright summer stars come close to matching Antares' crimson hue.

It's of little surprise that Antares is prominent in ancient legends — with the star's ruddy tint often symbolizing fire, blood and war. In fact, the name Antares is derived from the ancient Greek word meaning "rival of Ares" (or Mars in Roman mythology), god of war. Ironically, several American Indian tribes saw Antares as the "spirit star" where souls rested after a treacherous journey along the Milky Way which was seen as a roadway to heaven.

One of the so-called supergiant stars, Antares measures 400 times larger than our sun. Yet the red colossus is only 10 times our sun's mass, meaning that Antares' outer surface must be extremely tenuous —almost a vacuum. A relatively cool star, Antares glows with a surface temperature of 4,900 degrees Fahrenheit — roughly half the sun's temperature.

Appropriately, Antares marks the heart of an evil and deadly mythological creature — Scorpius the scorpion. Hera, wife of the Greek god Zeus and a troublemaker we've heard much about in Star Dome, sent Scorpius after Orion the mighty hunter to punish him for boasting no animal could ever harm him. One of nature's most insignificant creatures, the scorpion was an ideal selection. After Scorpius' poisonous sting killed Orion, his lover Artemis had Zeus place the hunter in the sky as a constellation. Jealous Hera demanded that Scorpius also be immortalized. Zeus cleverly placed Orion and Scorpius in two opposite seasons of the year so they never appear above the horizon at the same time.

Scorpius is one of the few zodiacal constellations resembling its namesake. From a T-shaped star pattern forming his head and claws, Scorpius' body extends downward through Antares. It ends in a fishhook shape, signifying the creature's deadly tail. From northern latitudes part of Scorpius' body disappears below the horizon, giving the impression he is rising out of his hiding place again to ambush another victim.

However, the monster is pointed toward the only inanimate object of the 12 zodiacal constellations, Libra the scales. Dominated by a parallelogram of four stars, this faint constellation once represented Scorpius' claws. The Romans transformed the claws into a pair of scales either in honor of Julius Caesar's wisdom and justice, or the goddess of justice, Astraea.

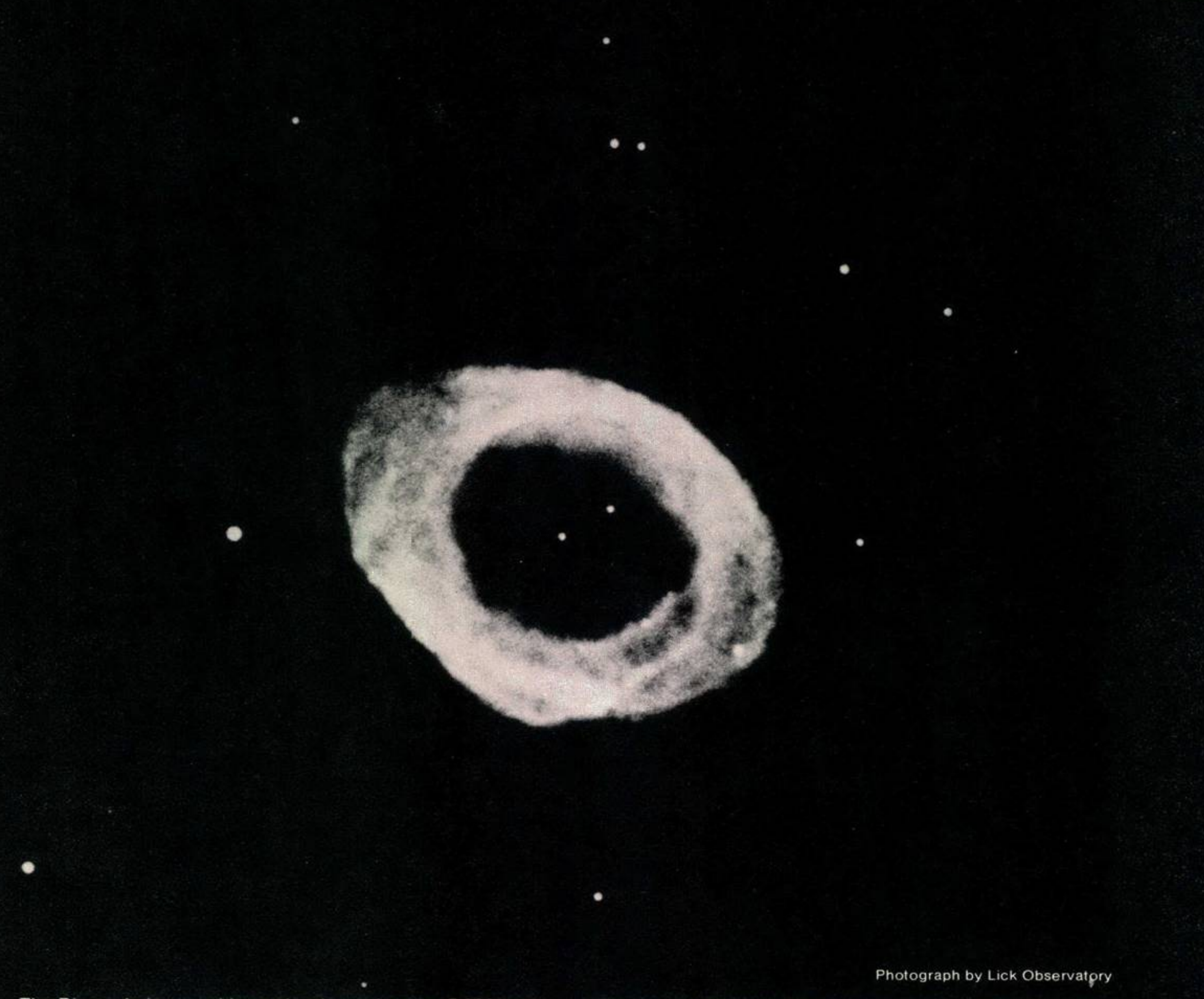
To Scorpius' left lies Sagittarius the archer, southernmost constellation figure of the zodiac. Instead of resembling an archer, the constellation's grouping of second and third magnitude stars traces out a teakettle which seems to be pouring scalding water over nearby Scorpius. Four stars shape the kettle's curved handle, a three-starred triangle the pointed lid, and third magnitude Al Nasi the spout.

To the ancient Greeks, Sagittarius represented Chiron the centaur (half-man, half-horse). As a creature of goodness and wisdom who "thought thoughts too great for man", Chiron stood apart from the rest of his breed which was notorious for its fierceness. Schooled in a variety of arts and sciences, Chiron tutored many of the Greek heroes including Achilles, Hercules and Jason. Because the centaur was an archery expert, his constellation figure is usually pictured holding a bow and arrow.

Although Chiron was the only immortal centaur, his Earthly existence came to an abrupt end because of Hercules. The mighty warrior had opened a jar of wine belonging to the centaurs' private stock. The centaurs detected the wine's aroma and immediately attacked Hercules. He easily fought off the creatures but accidentally wounded Chiron who was standing nearby. Because Chiron's mortal wound was extremely painful, Zeus allowed the centaur to die and be placed in the heavens as a constellation.

The most dominant star pattern occupying August skies lies roughly halfway between Sagittarius and the north star, Polaris. Appropriately named the "summer triangle", this large pattern's boundaries are marked by the brightest star in three constellations. First magnitude Altair in the constellation Aquila the eagle stakes the triangle's southern tip. Brilliant Deneb in Cygnus the swan and dazzling Vega in Lyra the harp locate the pattern's remaining corners.

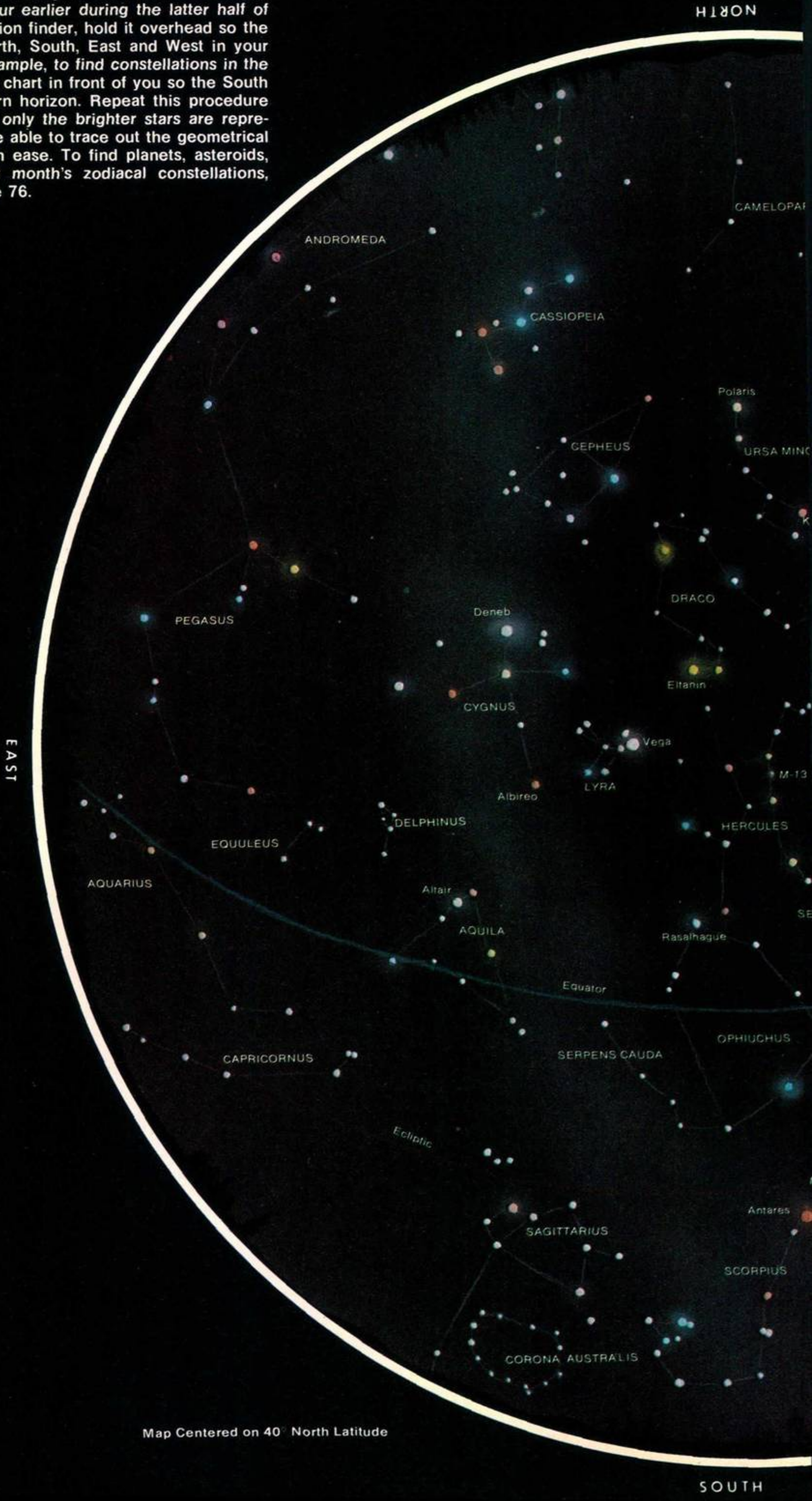
Lyra's small parallelogram of third and fourth magnitude stars is unmistakable. It outlines the mythological harp belonging to Orpheus, a mortal musician envied by the gods for his beautiful music. The harp's melodies had magical effects on creatures and inanimate objects. When Orpheus sailed with Jason and the Argonauts, his lyre easily drowned out the soothing but deadly voices of the Sirens who were notorious for luring crews to their doom.



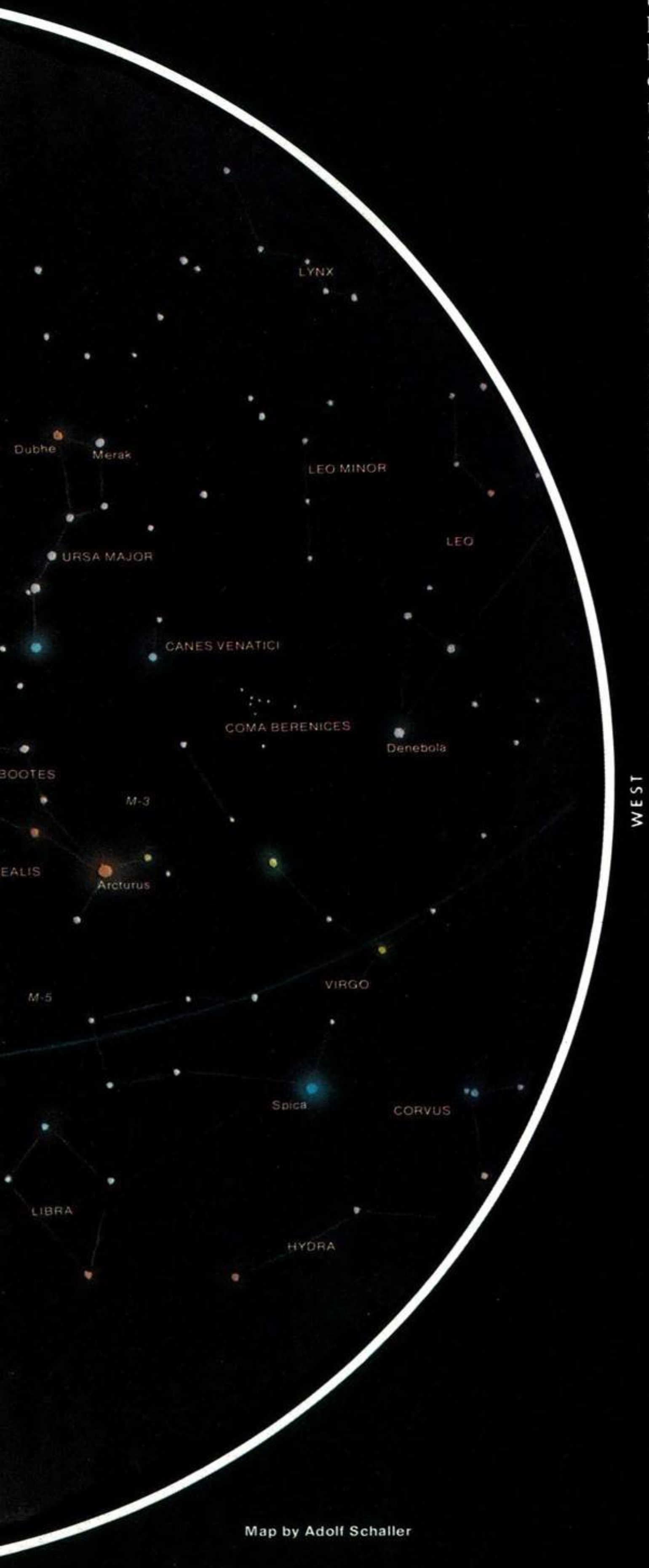
Photograph by Lick Observatory

The Ring nebula resembles a ghostly smoke ring. 5,000 light-years from Earth, this sphere of expanding gas is actually one light-year in diameter. The gas was mysteriously blown into space from a star at the center of the structure.

This Star Dome rendering approximates the sky as it appears at about 11 p.m. Local Daylight Time early in the month. The same constellations are visible one hour earlier during the latter half of the month. To use this constellation finder, hold it overhead so the compass points line up with North, South, East and West in your backyard or viewing area. For example, to find constellations in the southern part of the sky hold the chart in front of you so the South compass point faces the southern horizon. Repeat this procedure for East, West and North. Since only the brighter stars are represented in this map, you should be able to trace out the geometrical shapes of the constellations with ease. To find planets, asteroids, etc., visible among the current month's zodiacal constellations, refer to the planet finder on page 76.


NORTH
CAMELOPAR
ANDROMEDA
CASSIOPEIA
Polaris
URSA MIN
CEPHEUS
K
DRACO
Deneb
PEGASUS
Eltanin
CYGNUS
Vega
EAST
M-13
LYRA
Albireo
DELPHINUS
HERCULES
EQUULEUS
AQUARIUS
Altair
SE
AQUILA
Rasalhague
Equator
OPHIUCHUS
SERPENS CAUDA
CAPRICORNUS
Ecliptic
Antares
SAGITTARIUS
SCORPIUS
CORONA AUSTRALIS
SOUTH

Map Centered on 40° North Latitude



Map by Adolf Schaller

Orpheus also used the lyre to entice lovely Eurydice to marry him. But shortly after their wedding, Eurydice was killed by a viper and entered the kingdom of the dead. Orpheus' great love sent him into the underworld to rescue his bride. The lyre's music echoed through the gloomy darkness, casting a spell over the kingdom. The terrifying three-headed guard dog Cerberus became gentle, and tears of molten iron ran down Pluto's cheeks. Pluto (king of the underworld) allowed Orpheus to ascend to the surface with Eurydice providing he did not look back at her until they had both emerged into the sunlight. Seconds before Eurydice would have emerged from the cavern, Orpheus turned his head toward her — causing his young bride to vanish into the shadows forever.

Barred from trying a repeat performance, poor Orpheus led a lonely mournful existence until finally killed by the madwomen called the Maenads. Zeus pitied the musician and transformed him into a glittering constellation, Cygnus the swan, near Lyra in the sky.

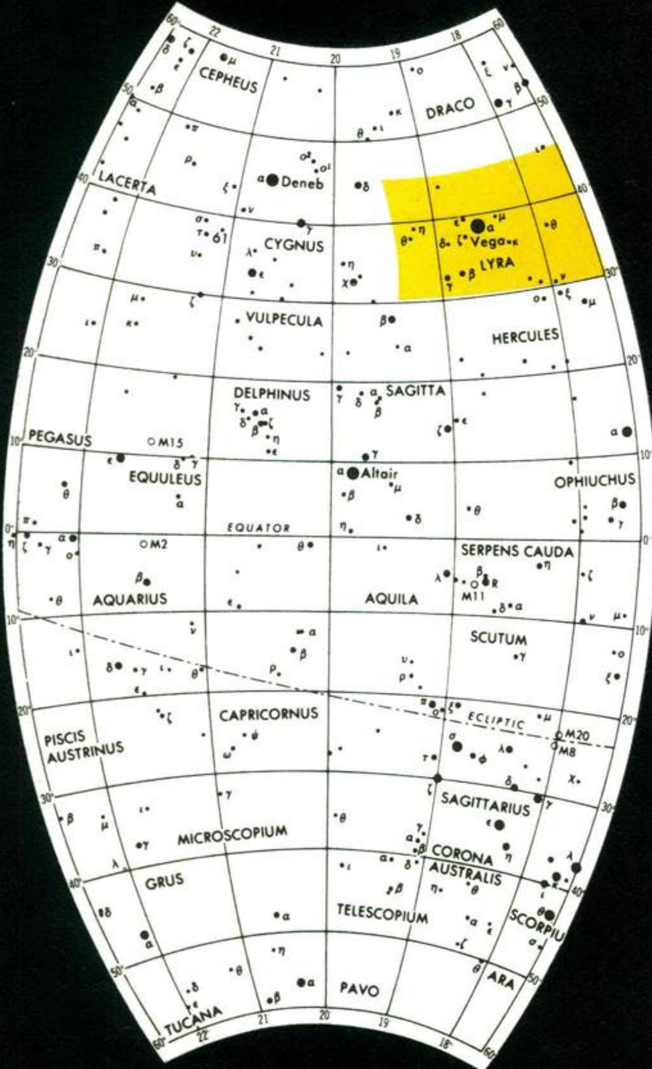
Close-up on the Lyra Region

Though Lyra is one of the smallest constellations, its stars decorate the late summer sky with more than enough delights to keep observers busy for considerable time. The most attention-grabbing member of the constellation is, of course, the falling eagle, Vega — fifth brightest star in the northern sky. This blazing blue solar furnace, three times the mass of the sun and twice as hot, is 27 light-years distant.

Vega's fame does not end with its brightness and beauty. The sun (and its solar system) move through the depths of space in the general direction of this star at 12 miles per second. This position is known as the "apex of the sun's way" or "the solar apex". The exact location of the solar apex has not been precisely determined, as widely different results have been obtained from studies using different sets of stars as reference points. Since Vega is also moving through space, no collision of the sun and Vega will occur. (Even if the sun were moving directly toward the star, it would take over 450,000 years to reach it.)

Gamma (γ) Lyra — with a magnitude of 3.25 and spectral class B9 — is probably the most valuable star to use as a comparison object for Beta (β) Lyra (featured in Eyepiece Impressions). It is just 1.7 degrees west and slightly south of Beta. (M-57, also featured in Eyepiece Impressions, lies between the two stars.) The star is 370 light-years distant, and is actually about 525 times more luminous than the sun.

Located halfway between and slightly west of Gamma and Vega is an interesting naked eye double


CEPHEUS
DRACO
LACERTA
Deneb
CYGNUS
Vega
LYRA
VULPECULA
HERCULES
DELPHINUS
SAGITTA
PEGASUS
M15
EQUULEUS
Altair
OPHIUCHUS
EQUATOR
M2
SERPENS CAUDA
AQUARIUS
AQUILA
M11
SCUTUM
CAPRICORNUS
ECLIPTIC
M20
M8
PISCIS AUSTRINUS
SAGITTARIUS
MICROSCOPIUM
CORONA AUSTRALIS
GRUS
TELESCOPIUM
SCORPIUS
PAVO
ARA
TUCANA
22
21
20
19
18
60°
50°
40°
30°
20°
10°
0°

Stars in each constellation are indicated, in order of brightness, with the Greek Alphabet

α	Alpha	η	Eta	ν	Nu	τ	Tau
β	Beta	θ	Theta	ξ	Xi	υ	Upsilon
γ	Gamma	ι	Iota	ο	Omicron	φ	Phi
δ	Delta	κ	Kappa	π	Pi	χ	Chi
ε	Epsilon	λ	Lambda	ρ	Rho	ψ	Psi
ζ	Zeta	μ	Mu	σ	Sigma	ω	Omega

Star Magnitudes
—1
0
1
1½
2
2½
3
3½
4
5
Cluster or Nebula
Variable Star

Map from **Guideposts to the Stars**, reprinted permission of MacMillan Publishing Co., ©1972 by Leslie C. Peltier.

TABLE OF OBJECTS – LYRA REGION

Object	Type	Magnitude	Size/Separation	Period	R.A. (1950)	Dec.
* Vega (Lyra)	blue star	0.0			18ʰ35ᵐ	+38°44'
* ε 1-2 Lyrae	quadruple star	5.1, 6.0, 5.1, 5.4	2.7" 2.3"		18ʰ43ᵐ	+39°37'
ζ 1-2 Lyrae	double star	4.3, 5.9	44"		18ʰ43ᵐ	+37°32'
* β Lyrae	variable double star	3.4-4.5, 7.8	47"	12.9 days	18ʰ48ᵐ	+33°18'
Δ 1-2 Lyrae	binocular double star	var., 5.5	12'		18ʰ52ᵐ	+36°54'
* M-57 (Lyra)	planetary nebula	9	83" x 59"		18ʰ52ᵐ	+32°58'
η Lyrae	double star	4.5, 8.7	28"		19ʰ12ᵐ	+39°04'
* M-56 (Lyra)	globular cluster	8.2	2'		19ʰ15ᵐ	+30°05'
RR Lyrae	prototype variable star	7.4-8.6		0.57 days	19ʰ24ᵐ	+42°41'

* Detailed description in Eyepiece Impressions

star with a distinct color contrast, Delta (δ) Lyra. Delta-1 (spectral class B3) shines at magnitude 5.5, while Delta-2 (spectral class M4) is a small range variable with the luminosity of 1,300 suns. Several other stars from 7.5 to 10th magnitudes lie in the group and form a scattered cluster. Its distance of about 800 light-years makes it one of the closest clusters, and its color-magnitude array indicates it is fairly young — comparable in age to the Pleiades star cluster in Taurus.

A fainter but important star found in the boundaries of the Lyra region is RR Lyrae, the first star identified as a typical example of pulsating variable stars with short periods of less than a day and low luminosities. RR is located about 50 degrees right ascension west and 4 degrees declination north of Vega, varying in brightness from 7.1 to 8.0. It is a white star whose spectral class changes from A to F during its light cycle.

RR variables are often called *cluster variables* since they are found in great abundance in globular clusters. Not one is close enough to be a naked eye object. Discovered in 1901, RR Lyrae itself is still the brightest known member of the class.

Eyepiece Impressions

Vega

This dazzling blue-white diamond — leader of the constellation Lyra — rides overhead on late summer evenings, ruling the heavens like some lone monarch in isolated splendor. Stars are often compared with gems — especially the radiant diamond — and perhaps no other object in the sky is better suited for comparison than Vega.

Webb saw this mighty star as "...pale sapphire — a lovely gem." However, the best classic description has to be that of Barns in his **1001 Celestial Wonders**, where he says this object "resembles an old mine Brazilian brilliant of purest water intensified to infinity!" In large refracting telescopes (12 inches and over) having a slight "blue excess" in their color correction, Vega is nearly pure blue with flashes of deep violet and purple flooding the field of view — a truly amazing sight.

In the July 1975 issue we discussed the technique for viewing the striking diffraction disks and rings of the bright stars by using high magnification with apertures of three inches or less (masking down larger instruments). It is interesting to compare the contrasting hue of Arcturus in our sketch last month with that of Vega presented here.

Aside from its intense color, this object has a faint companion about a minute of arc to the south. Rather difficult to see with less than a six inch telescope, this star presents a fine magnitude contrast with its primary in larger instruments. Numerous other faint stars can be seen in the field at greater distances, as Vega lies near the star-rich Milky Way border.

Historically this star is of considerable importance, for in the remote past it served as our polestar. Due to the slow precession of Earth on its axis, it will again assume that role some 12,000 years from now. More recently, Vega was the first star ever photographed — at Harvard Observatory in 1850.

Due to its high northerly declination, Vega is visible at some hour of the night every night of the year — making it a constant companion for the sky watcher. Its lovely blue light requires 26 years to traverse the distance from the star's hot surface to our eyes.

Epsilon (ϵ) Lyrae

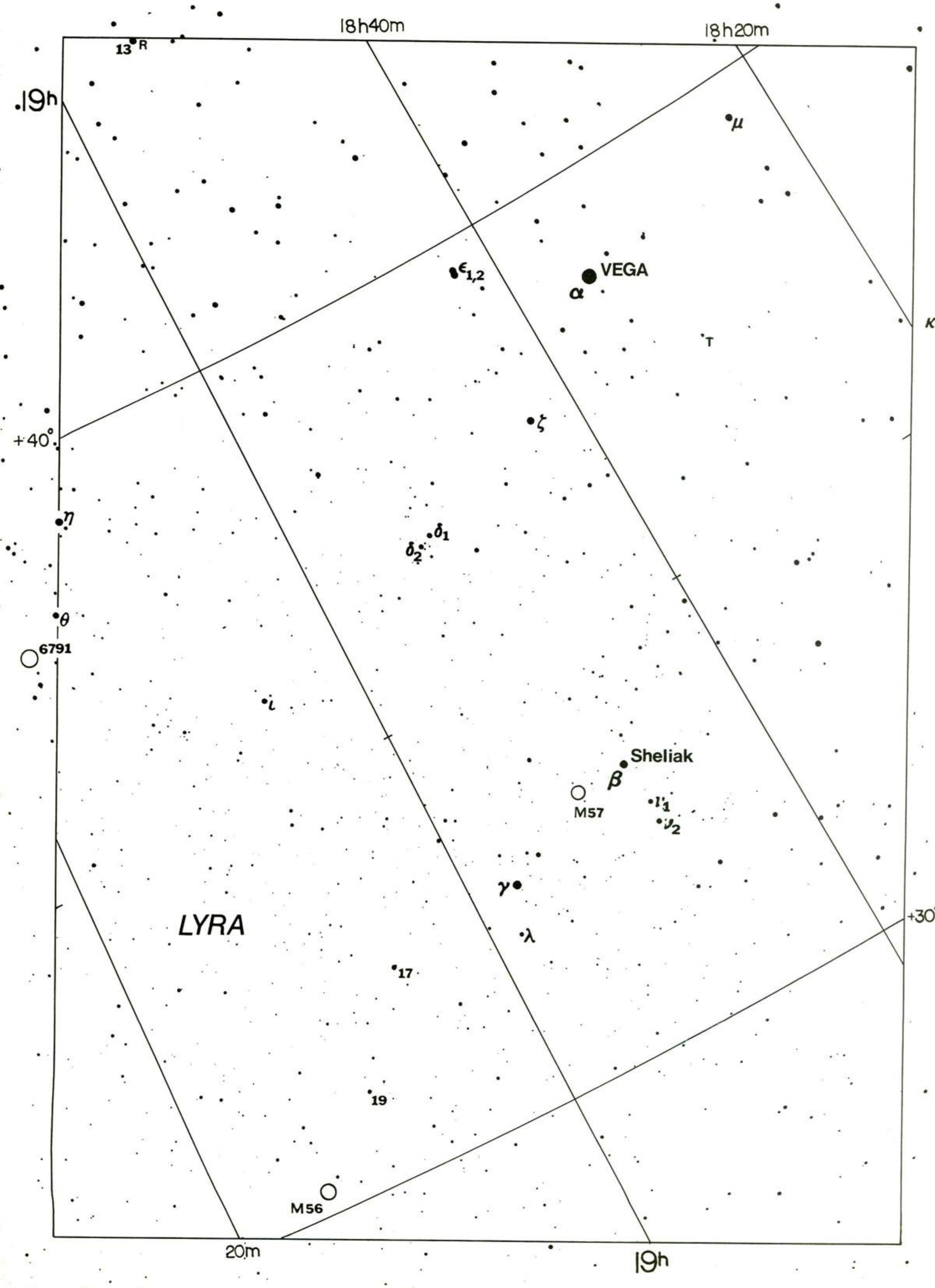
"The naked eye sees an irregular looking star near Vega, which separates into two pretty wide ones under the slightest optical aid. Each of these two will be found to be a fine binary pair." Thus, Admiral Smyth long ago described the star Epsilon Lyrae, just three degrees northwest of Vega — and today known as the *double-double*. This exquisite object is the finest quadruple star in the sky.

It is important for beginning observers to note that the separation between Epsilon-1 and Epsilon-2 is more than three minutes of arc, for this star is often confused with nearby Zeta (ζ) Lyrae (also a double in finders and binoculars). Zeta's components are less than a minute apart, and no amount of magnification on any telescope will show them as doubles.

William Tyler Olcott spoke for most observers in calling the double-double "a marvelous object" — for so it is. Separated by 208 seconds of arc, we find two close pairs of stars. One consists of 5.1 and 6.0 magnitude stars, 2.7 seconds apart; the other 5.1 and 5.4 magnitude suns, 2.3 seconds from each other. The position angles, or lines, joining the close pairs are turned about 90 degrees with respect to each other.

All four stars can just be resolved with 75 to 100 power on a good 2.4 inch (60mm) refractor. In three inch and larger telescopes, this object is truly a celestial spectacular. The individual stars appear white in color, but various subtle tints have been reported by different observers — such as greenish-white and blue-white for the one pair, and yellow and rose or tawny for the other. Strangely, the components seem relatively insensitive to seeing conditions compared to other close doubles having the same separations.

The double-double is all one vast binary system — the closer duo completing an orbit every 600 years, and the wider one every 1,200 years. In addition, the two pairs are slowly circling each other about a common center of gravity with a period esti-



18h40m
18h20m
13 R
19h
μ
ε1,2
VEGA
α
κ
T
ζ
+40°
η
δ1
δ2
θ
6791
ι
Sheliak
β
M57
ν1
ν2
γ
LYRA
λ
+30°
17
19
M56
20m
19h

mated in the millions of years! All four suns lie about 200 light-years from us.

Beta (β) Lyrae

Southeast of Vega, at one corner of the parallelogram in Lyra, is the third magnitude — sometimes fourth — star Beta Lyrae, an exciting member of the class of variable stars known as *eclipsing binaries.* It is also an attractive multiple star for small telescope users.

Beta's light output varies by more than a magnitude (3.4 to 4.5) with a period of 12.9 days. The fluctuations can easily be noticed with the unaided eye by making frequent comparisons with surrounding stars such as Gamma (γ). This variation was, in fact, discovered without a telescope by Goodricke, an English deaf-mute, in 1784. He also studied the light curve of Algol without optical aid.

The brightness changes in Algol, Beta Lyrae, and others like them, are not intrinsic, but rather are caused by less luminous companion stars periodically eclipsing all or part of the brighter star as they orbit about each other. We actually witness the revolution of a distant sun about another with no other equipment than the human eye.

The Beta Lyrae system is under intensive study by astronomers around the world, for the involved stars are going through evolutionary changes right before our eyes. So important is this system that the late Otto Struve, who made a lifelong study of this object, once half seriously suggested that a 100 inch telescope be built just for continuous monitoring of Beta.

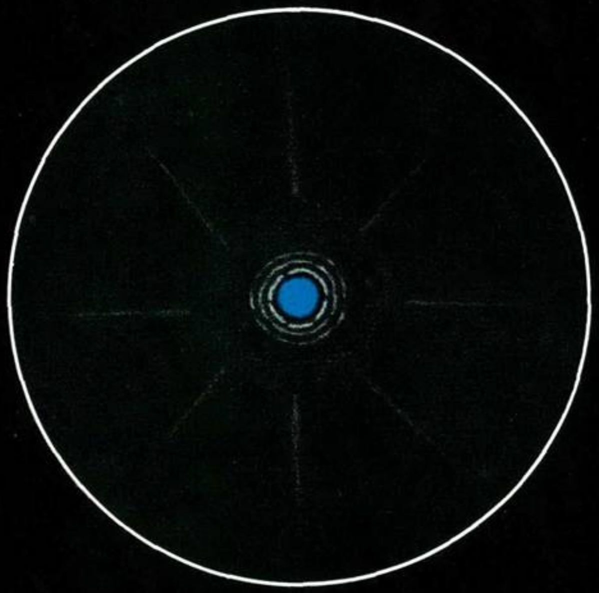
In addition to its light variations, Beta is also a visual double star, having a 7.8 magnitude companion 47 seconds away. Its blue color contrasts nicely with the yellow primary, especially in six inch and larger telescopes. There are two fainter attendants at roughly equal distances, making this object an apparent multiple star. The three companions form a striking triangle about Beta as shown in our drawing.

M-57

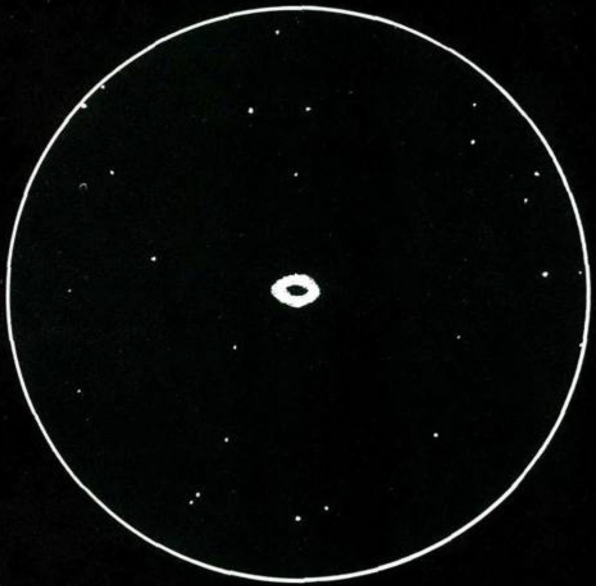
Slow sweeping of the area between Beta and Gamma Lyrae with 30 or 40 power on your telescope will reveal a small misty disk of light. This is the famous Ring nebula, the finest example of a planetary nebula in the heavens.

This giant, stellar smoke ring is frequently pictured in astronomy books (see June 1975, page 21), and visually is anything but disappointing. Glowing at ninth magnitude, M-57 is one of the very brightest objects of its class. Larger in apparent diameter than the planet Jupiter, its elliptical outline (83 by 59 seconds of arc) is obvious in the smallest of telescopes.

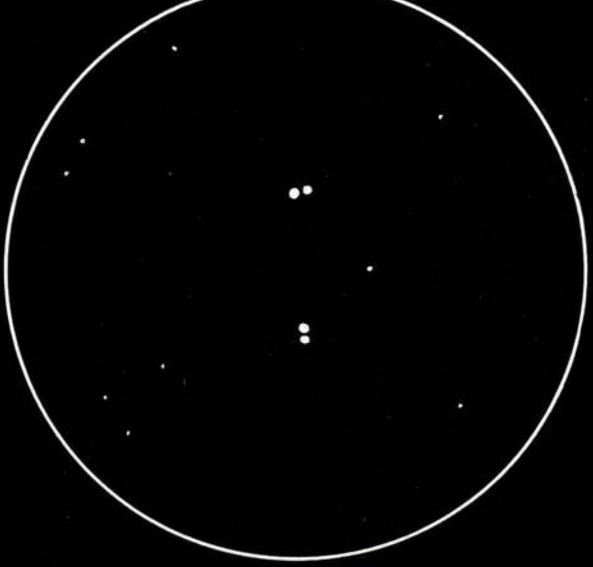
The central hole has been glimpsed at just 40 power on a 2.4 inch refractor, and is obvious at 75 power on a three inch. With six and eight inch reflectors at moderate magnification, delicate differ-



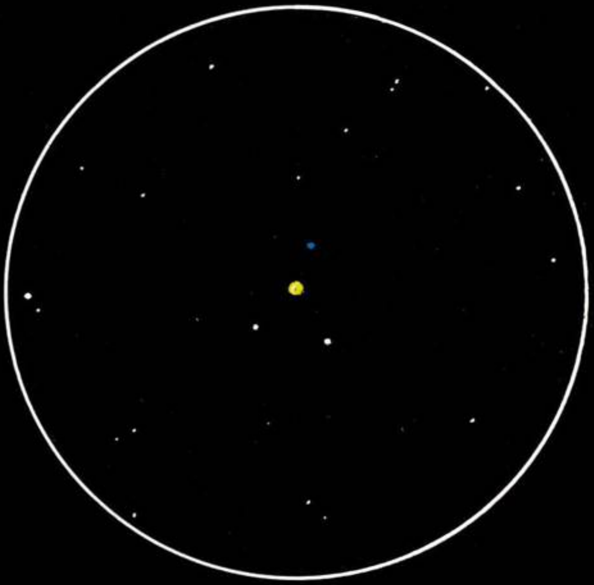
Vega, Lyra's brightest jewel, shines with blinding light when seen at 150 power through a three inch Unitron refractor masked down to one inch. The field of view is approximately 10 minutes of arc.



The ghostly M-57, or Ring nebula, is a striking object when seen through a 75 power eyepiece on a five inch Celestron. It is also a fairly easy nebula to locate in tiny Lyra. The field of view is approximately 1/2 degree.



Epsilon Lyrae, the constellation's "double-double", appears as four brilliant dots when viewed at 125 power through a four inch reflector. The 20 minute field of view shows an additional sprinkling of stars.



The beautiful multiple star Beta Lyrae is easily separated with a 70 power eyepiece on a six inch Cave Astrola reflector. This eyepiece and telescope combination offers a field of view of approximately 40 minutes of arc.

Sketches by James Mullaney

ences in brightness within the ring of gas can be seen — as well as the fact that the dark hole is slightly luminous compared to the sky background. In 10 and 12 inch instruments, M-57 looks very much like it does in a black and white photo.

Barns rates this object, "Finest of the annular type. A cardinal unit." Webb states that the Ring nebula bears magnifying well and calls attention to a curious feature: "Its light I have often imagined fluctuating and unsteady, like that of some other planetary nebulae; an illusion arising probably from an aperture too small for the object." And thus it appears today. A four inch reflector at 70 power, for example, often shows this effect with the use of averted vision. If Webb is right about insufficient aperture, the flickering should be reduced or absent in large amateur instruments. Perhaps well equipped ASTRONOMY readers might like to verify this.

Photos often show a faint central star within the nebula, However, this is an extremely difficult object to see visually, being at least 14th magnitude. A 12th magnitude star just following (east) the Ring should be readily seen before seeking the central star. Well dark-adapted eyes, use of averted vision and dark clear nights are essential for success even with really large instruments. James Mullaney, our Star Dome contributing editor, has glimpsed the star in a 13 inch refractor at 190 power and found it obvious in a 30 inch refractor and 30 inch reflector at 600 power.

Various estimates of M-57's distance place it as far as 5,000 light-years away.

M-56

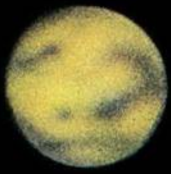
Approximately midway between Gamma Lyrae and Beta Cygni (Albireo), nestled in a dense stellar forest, is a remote beehive of suns designated M-56. Having the combined light of an eighth magnitude star and some two minutes in diameter, this globular cluster is easily swept up in three and four inch telescopes at 45 power.

Closer inspection, especially with six inch and larger apertures, reveals a granular texture — the precursor of resolution. The eye is seeing clumps of unresolved stars within the cluster. Webb calls M-56 "...faintish, perhaps resolvable with a 3.7 inch, in fine field and rich region." Smyth's description is "...a globular cluster in a splendid field," while Barns curiously labels this object a "semi-globular cluster", and adds the comment "neighborhood radiant".

Although no match for showpieces like M-3 and M-13, this cluster has a charm about it that makes the observer return to it time and again. We view M-56 in the halo of our galaxy, more than 45,000 light-years distant.

In viewing the many treasures of Lyra, it is well to consider — as one observer has pointed out — that "It is not accident that wherever we point the telescope we see beauty...."

Planet Finder



Ⓒ Cere

August	1	15
R.A.	4^h04^m	4^h21^m
Dec.	+1°27'	+15°2
Mag.	+8.5	+8.5

Ⓐ Mercury

August	1
R.A.	8^h50^m
Dec.	+19°57'
Mag.	-1.7

Ⓑ Mercury

August	15
R.A.	10^h35^m
Dec.	+18°10'
Mag.	-0.5

Ⓜ Mars

August	1	15
R.A.	3^h19^m	3^h55^m
Dec.	+16°49'	+19°02'
Mag.	+2.0	+2.0

Ⓝ Neptun

August	15
R.A.	16^h30
Dec.	-20°15
Mag.	+7.7

SUN

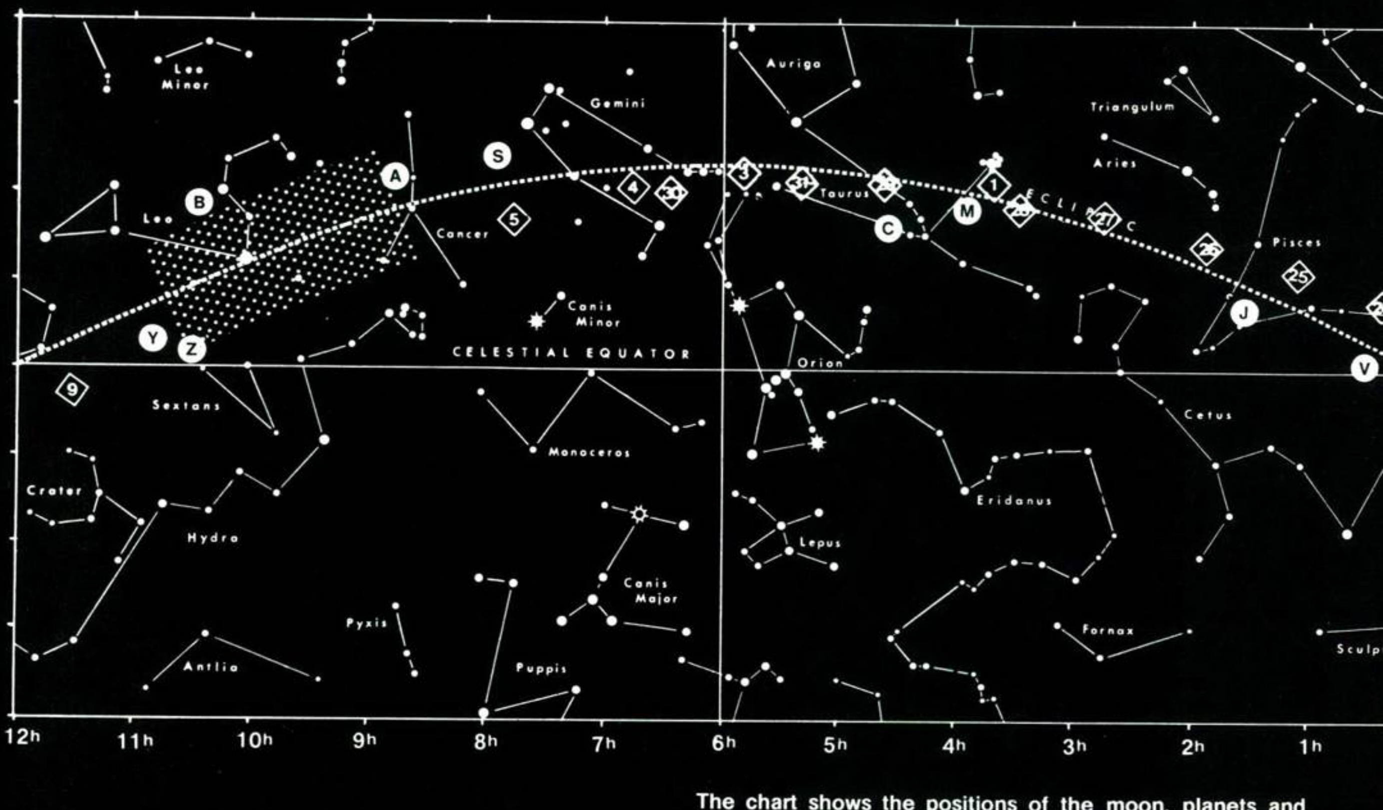
The sun is within the stippled zone throughout the month. Planets and stars near this area are not easily seen.

Ⓢ Saturn

August	1	15
R.A.	7^h46^m	7^h54^m
Dec.	+21°10'	+21°51'
Mag.	+0.4	+0.4

Ⓤ Uranus

August	15
R.A.	13^h48^m
Dec.	-10°39'
Mag.	+5.7


Leo Minor
Gemini
Auriga
Triangulum
Aries
Leo
B
A
S
Cancer
Taurus
C
M
ECLIPTIC
Pisces
4
30
5
3
31
1
27
26
25
J
Canis Minor
Y
Z
CELESTIAL EQUATOR
Orion
V
9
Sextans
Monoceros
Cetus
Crater
Eridanus
Hydra
Lepus
Canis Major
Pyxis
Fornax
Antlia
Puppis
Sculp
12h
11h
10h
9h
8h
7h
6h
5h
4h
3h
2h
1h

The chart shows the positions of the moon, planets and brightest asteroids for the current month. Letters within the circles correspond to the letters beside each object in the data section above the map. Additional information about each object is given there. R.A. = right ascension and Dec. = declination, the two coordinates used to locate astronomical objects. The general coordinate system is indicated around the edge of the map. Mag. = magnitude, a

August 1975

Ⓥ **Vesta**

ugust	1	15
.A.	0^h21^m	0^h21^m
ec.	+1°19'	+1°20'
ag.	+7.0	+7.0

Ⓙ **Jupiter**

August	1	15
R.A.	1^h32^m	1^h33^m
Dec.	+8°09'	+8°12'
Mag.	-2.2	-2.2

Ⓨ **Venus**

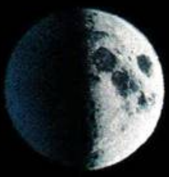
August	1
R.A.	10^h45^m
Dec.	+3°37'
Mag.	-1.4

Ⓩ **Venus**

August	15
R.A.	10^h35^m
Dec.	+1°28'
Mag.	-3.7

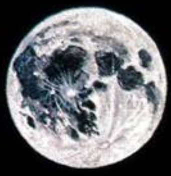
Ⓟ **Pluto**

August	15
R.A.	12^h52^m
Dec.	+12°18'
Mag.	+14



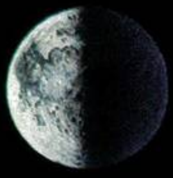
First Quarter

August 13



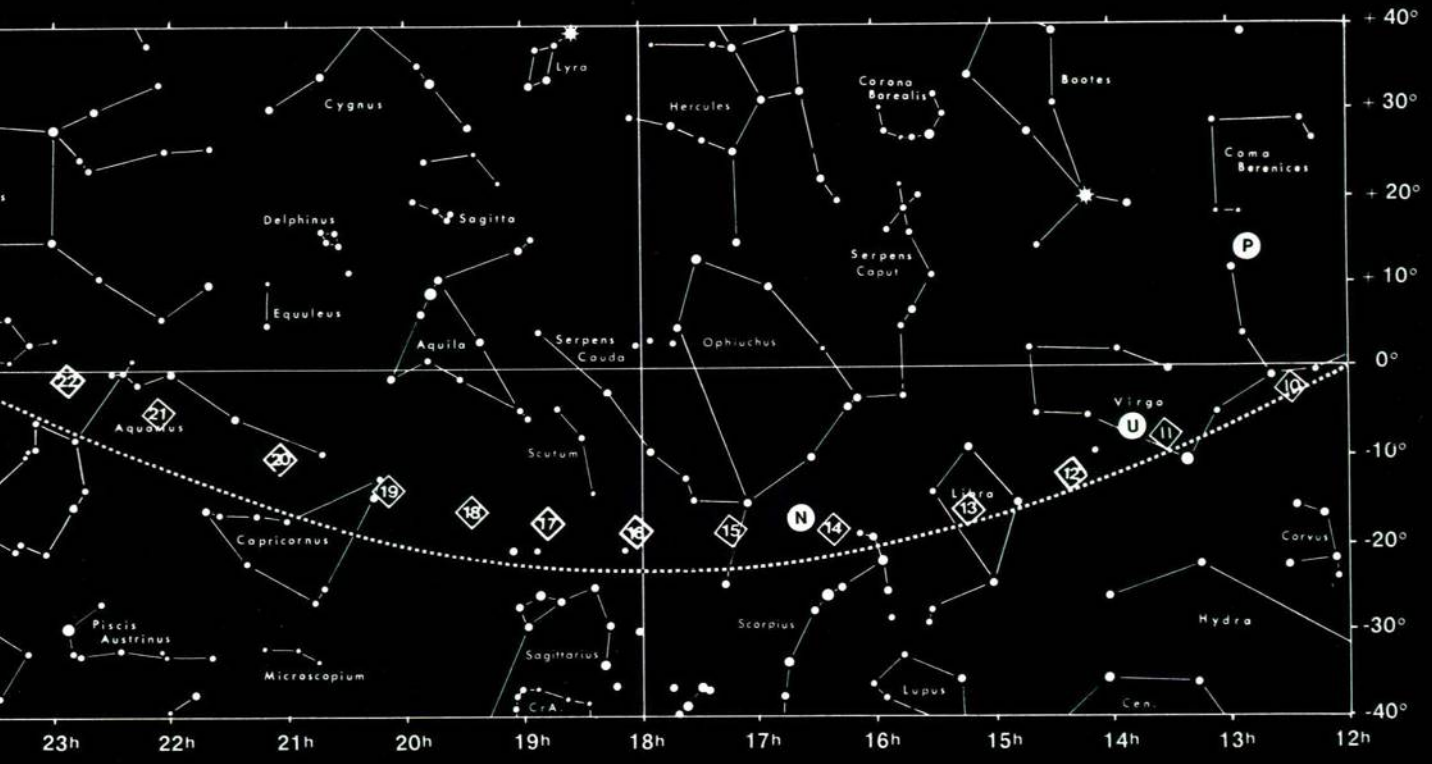
Full Moon

August 21



Last Quarter

August 29



+40°
+30°
+20°
+10°
0°
-10°
-20°
-30°
-40°
Lyra
Cygnus
Hercules
Corona Borealis
Bootes
Coma Berenices
Delphinus
Sagitta
Serpens Caput
Equuleus
Aquila
Serpens Cauda
Ophiuchus
Virgo
Aquarius
Scutum
Libra
Capricornus
Corvus
Hydra
Scorpius
Piscis Austrinus
Sagittarius
Microscopium
Lupus
CrA.
Cen.
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22h
21h
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19h
18h
17h
16h
15h
14h
13h
12h

measurement of the object's brightness. (The minus magnitudes indicate very bright planets.) The diamonds with numbers within them indicate the position of the moon for each day of the month; the numbers correspond to the dates. Positions of the planets are for the 15th of the month except for Mercury and Venus which are shown on both the 1st and 15th. Certain areas of this map and the Star Dome chart overlap each month.

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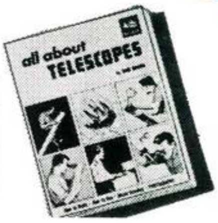

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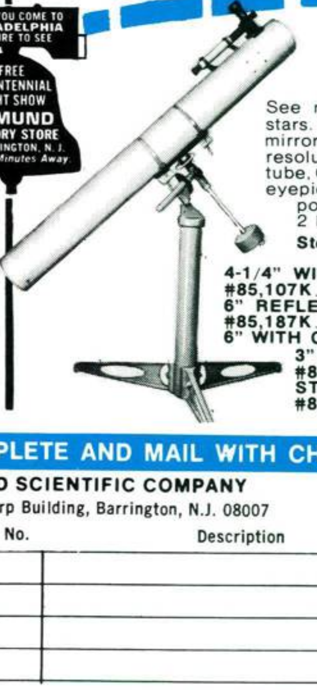

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